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THE OHIO JOURNAL OF SCIENCE

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THE USE OF WEATHER BUREAU DATA IN ECOLOGICAL STUDIES[1]

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For well over a century ecologists and foresters have included in their reports of investigations of local areas, summaries of climatic data from nearby weather stations. These summaries may reflect the macroclimate of a region, thus serving to locate the area in plains, desert, forest or tundra. But they do not account for the various biotic phenomena described, such as occurrence, growth, survival, succession, reproduction and death of plants and animals. Rarely do the authors make any statements concerning relationships between these factors and the biological phenomena observed in the field. It may be that there are none that are cause and effect relationships.

The meteorological data obtained at Weather Bureau stations form the basis for generalized concepts of phenomena making up a regional climate. These regional climates are clearly recognizable, and in this sense, are comparable to the generalized soil types such as Marbut (15) has recognized in his delineation of the major soil types of the United States. But the pedologists have gone further, mapping local variations in soils within the great divisions. Ohio, for example, lies within one of the nine divisions known as the gray-brown podzolic soils province. But in Licking County alone, 56 types and phases are recognized and mapped (32). In the more deeply dissected terrain of Adams County, 68 types and phases are mapped (24).

Studies of local climatic differences, or microclimatic types, comparable to these studies of the pedologists have scarcely been begun by climatologists, although the local microclimates are similarly varied and complex. Moreover, these local atmospheric conditions are the climates in which plants actually live.

Field reports of ecological investigators invariably include analyses of soil factors, most of which have been directly measured in the problem area. But oddly enough, local climatic conditions have been measured only occasionally within the field of survey. Climatic data from the very beginning of meteorological measurements, have been obtained from regular meteorological stations, and here from instruments housed in "standard shelters," located one to 50 miles from, and at elevations several feet to a mile above or below, the areas studied.

Thornthwaite and Leighly (27) remark that "the climate of a region as determined by means of these standardized observations is more or less of an abstraction." Geiger (9) has called the climate determined through data obtained by these methods "human climate," *i. e.*, climate based on weather elements in which humans are most interested with regard to transportation, physical comfort, recreation, harvesting of crops, sale of merchandise, and the like. In short, it is the weather around our heads, physically and psychologically, and

[1]Publication No. 477, Department of Botany, The Ohio State University.

does not even remotely resemble the weather experienced by plants and animals at our feet.

But whatever the label applied to the interpretation of these enormous quantities of data accumulated at stations all over the world, they have been exceedingly significant in at least three respects:

1. They have resulted in a knowledge of the pattern of "human climate" over large areas, probably reaching the best expression in North America in Thornthwaite's classification (25); and for the world in Köppen's system (13).

2. They have enabled climatologists to compute the variation of climatic factors in different large areas for years, decades and centuries, and also the same area from year to year.

3. They have brought out a recognition of the duration, extent, intensity, and the periodicity, of certain phenomena such as drouth, precipitation and temperature conditions. For example, Visher (30) has utilized Weather Bureau precipitation data as a basis for his maps showing distribution of excessive rainfall. This distribution correlates closely with the Southern Coastal Plain forest formation. Kincer (11, 12) has shown the temperature trend to be upward all over the world during the past century, basing his conclusions on the accumulated data at a number of metropolitan stations with long weather records.[2] Marvin (16) has recognized definite precipitation trends of 50 to 100 years at Boston. Thornthwaite's evaporation-precipitation index maps (26) show a remarkable similarity to the known periodic fluctuations in the boundaries between original forest and prairie, and prairie and grassland formations.

The files of the Weather Bureau also constitute a vast repository of data likely to be of much value when finally analysed and interpreted. In addition to the actual temperature and precipitation data, many cooperative observers have listed quantities of phenological data, such as the times of bird migrations, the breaking of buds, the flowering of plants, the appearance of certain mushrooms and the maturing of various crops. The original records may be a rich source of such data, which, as Wing (33) remarks, "may be better for some wildlife comparisons than the temperature records themselves." The observations of Thomas Mikesell at Wauseon, Ohio, for a period of 40 years are outstanding examples. These are probably the most extensive and complete phenological records in North America, and they have been compiled and published by Smith (22).

In general, however, the Weather Bureau has been most active as a public service through its weather predictions. In fact, its primary function has been the forecasting of weather. The accumulation, analysis and interpretation of climatic data have been secondary because of limitations of available personnel.

USE OF WEATHER BUREAU DATA IN ECOLOGICAL REPORTS

It is not the regional factors, however, that control the behavior of plants and animals that live, grow, reproduce and die in the multitude of different habitats in large biotic areas like deciduous forest, prairie, or tundra.[3] Yet, even the most recent ecological literature is replete with uninterpreted Weather Bureau data. The following are only a few random examples. Gates (8), in his paper on the bogs of northern Lower Michigan, states that "the climatic conditions most closely resemble those of the Weather Bureau station at Cheboygan, Michigan," one to 100 miles north of the various bogs and between two of the largest lakes in North America. This remarkable statement, completely contrary to the findings of Cox (6), is followed by some data from this distant station. Pearson (19)

[2]Studies now in progress in the Botanical Laboratories at The Ohio State University indicate that this trend is not as pronounced in rural areas as it is in metropolitan centers, the source of most of Kincer's data.

[3]For another point of view, see Cain's quotation of Clements (2), pp. 11 and 21.

in his paper on the effect of herbaceous vegetation on the regeneration of *Pinus ponderosa*, cites precipitation data from a station six miles away from the experimental plot. Purer (20), who studied the ecology of the salt marshes along 40 miles of the California coastline, refers to temperature, sunshine and precipitation data recorded at San Diego, 35 miles from the farthest station. Stoeckler and Limstrom (23) published a paper on factors influencing reforestation in northern Wisconsin. The area in which the studies were conducted is 10 miles southwest of the station from which the climatic data were obtained. Brown's meticulous 10-year study of Roan Mountain (1) included data recorded at two stations 15 and 18 miles away, and at elevations 2,535 and 4,710 feet, respectively, below the problem area. Oddly enough, length of day, one of the most significant of ecological factors, is rarely mentioned.

MACRO- VERSUS MICRO-METEOROLOGY

The climatological and ecological literature, however, is not without reports showing that conditions, as measured by Weather Bureau standards, are sometimes astonishingly dissimilar from nearby, or even adjacent, plant and animal habitats. Wolfe, Wareham and Scofield (34) report frost free periods of seven different lengths in different habitats of a mile-long valley in central Ohio, ranging from 124 to 256 days. For the same year (1941), a Weather Bureau station nine miles away recorded a frost free period of 144 days. They also show that the annual minimum temperatures varied in the habitats in the valley from —25° F. to +32.5° F., compared to the official minimum of —18° F. Annual maximum temperatures varied from 76° F. to 120° F., and the dates of the annual maximum temperatures varied from April to August at the different stations.

The same authors report that the date of the last spring frost in 1941 in the valley varied from April 3 to May 25. These dates are almost identical to the official figures for the whole state of Ohio for 1941. At the 88 Ohio stations the last spring frost came between April 2 and May 25 (4). Thus the frost dates of various stations in a small valley less than a mile in length showed as much variation in 1941 as did the whole network of Weather Bureau stations in the state. Data for the first fall frost are even more striking. In the valley the first frost-dates in autumn were recorded from September 26 to December 13. The range for Ohio's 88 stations was October 11 to November 10 (4).

Cox (5), in an intensive four-year study of thermal belts in North Carolina, found, among other things, that the length of the growing season varied from 100 to 232 days at 60 stations. The same author (6), in his pioneer microclimatic study of cranberry bogs in Wisconsin, published a vast amount of soil and air temperature data showing that "great extremes of temperature occur in any bog and there is a wide range of minimum temperature in the same bog," further remarking that when the Weather Bureau station at Lacrosse (20 miles from nearest bog) reports prospective temperatures below 50° F., frost can be expected in the marshes if the night is clear. His report supporting this statement is too detailed for summary here. Malde (14), whose work is in agreement with that of Cox (6), increased the average length of the growing period in Wisconsin bogs from 58 to 118 days by application of sand. The averages are based on an 11-year study. Sinclair (21), working on maximum air temperatures in the desert, found great variation between the levels at 4, 12, 32, 65, 114 and 175 cms. above the soil surface through summer days. Maximum temperature of 122° F. at 4 cms. occurred at 1:00 p. m. At the same hour, the temperature at 175 cm. was 15° lower.

These are only a few examples, but there are many others, some of which are discussed by Geiger (9) in his systematic treatment of "the climate of the layer of air near the ground."

SPATIAL VARIATION IN PRECIPITATION

Spatial variation in rainfall within small areas has been shown by Turnage and Mallore (28), Humphrey (10) and Musson (17) to be very great, sometimes the highest readings differing as much as 30 per cent from the lowest. The numerous maps and tables showing variation in amount of precipitation published by the Muskingum Conservancy Project reveal striking differences in different stations of the Muskingum watershed. The Weather Bureau records themselves, sometimes show great differences in amount of precipitation at stations near each other. The correlation of these figures with biotic phenomena is difficult in light of the data in Table I, from two stations near each other in Muskingum County, Ohio (4).

TABLE I

DIFFERENCES IN AMOUNTS OF PRECIPITATION PER DAY AT PHILO (1) AND PHILO (2)[a]; MUSKINGUM COUNTY, OHIO, IN 1943

Precipitation Difference of:	Number of Days per Month With Varying Amounts of Precipitation												
	Jan.	Feb.	Mar.	Apr.	May	Jun.	July	Aug.	Sep.	Oct.	Nov.	Dec.	Total
Less than .10 ins.....	16	15	6	14	14	4	7	5	8	8	10	11	118
Between .11–.25 ins.....	5	1	5	3	5	3	7	0	1	0	1	0	31
Between .26–.50 ins.....	1	1	1	2	4	2	2	1	0	1	1	0	16
Between .51–1.00 ins....	0	0	3	0	0	1	0	0	0	1	0	0	5
Over 1.00 in.....	0	0	0	0	0	1[b]	0	2[c]	0	0	0	0	3
Total days ppt.....	22	17	15	19	23	11	16	8	9	10	12	11	173

[a] Station 2½ miles S.W. of Philo, where (1) is located.
[b] 1.36 ins. at Philo (1); .15 ins. at Philo (2) on June 16.
[c] 1.85 ins. at Philo (1); .40 ins. at Philo (2) on August 4.
1.02 ins. at Philo (2), none at Philo (1) on August 5.

While 68 per cent of the total days with at least a trace of precipitation have essentially the same amounts at the two stations, the differences appear to be ecologically significant, especially when using the data in conjunction with seasonal or short-time investigations. Moreover, the major differences occur in the midst of the so-called growing season. These differences may be averaged and the total annual precipitation at two stations located so close together become nearly identical. But in 1943 the total at Philo (1) was 29.25; at Philo (2) 34.24, with monthly differences of 1.10 and 1.04 inches in June and August respectively.

TABLE II

DIFFERENCES IN PRECIPITATION AT TWO FIRST ORDER WEATHER BUREAU STATIONS AT CINCINNATI, OHIO[a] FOR THE 1943 GROWING SEASON

Precipitation Differences of	Apr.	May	June	July	Aug.	Sept.	Total
Less than .10 ins.....	17	21	11	9	7	10	75
Between .11–.25 ins.....	3	2	3	1	1	1	11
Between .26–.50 ins.....	0	2	0	5	4	2	13
Between .51–1.00 ins.....	0	0	2	1	0	0	3
Over 1.00 ins.....	0	0	1[b]	0	0	0	1
Total days with ppt.....	20	25	17	16	12	13	103

[a] Stations are located at the Abbe Observatory and the Federal Building, about 3.4 miles apart.
[b] Abbe .55 in.; Fed. Bldg. 1.59 ins. on June 10.

While readings of instruments at the cooperative stations may not always be made at exactly the same hour each day, thus inserting error into the daily comparisons, similar results are obtained in comparing two first order stations at Cincinnati. (Table II).

Moreover, these data usually are concerned only with amount. It has long been recognized that time of precipitation, nocturnal or diurnal; the season, type, amount of interception, run-off, and evaporation are also important ecological factors. But total and average precipitation data are all that are usually published by ecologists, often from stations 20–50 miles from the problem area. It seems useless, therefore, to cite precipitation data not obtained in the problem area. The precipitation data represented by Fig. 1b, for example, implies a rather uniform distribution through the seasons at Lancaster, Ohio. Figs. 1a, c plainly show that this is not true, and may frequently be misleading.

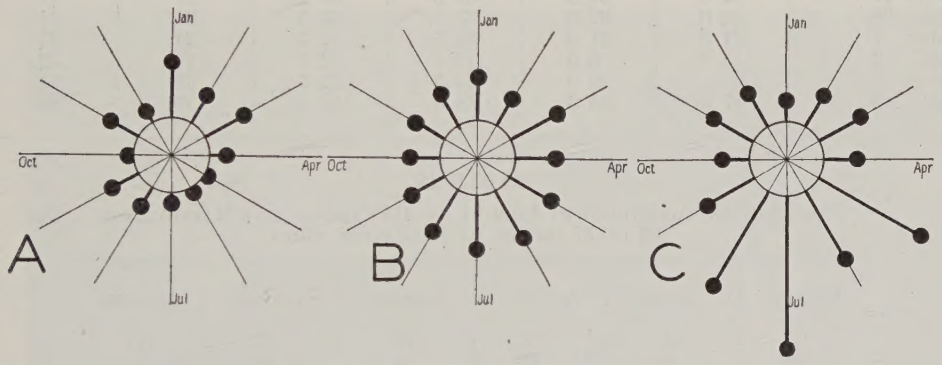

FIG. 1. Precipitation rosettes for Lancaster, Ohio. A, monthly precipitation in 1930, showing year-round drouth conditions; B, mean monthly precipitation giving the impression of rather uniform seasonal distribution; C, monthly precipitation in 1920, showing winter drouth and abundant rainfall during crop growing seasons.

WEATHER BUREAU METHODOLOGY AND PROCEDURES

Weather Bureau methodology and procedures fail to furnish useable ecological data, *i. e.*, data reflecting actual habitat conditions of plants and animals, for several reasons.

1. *Location, Housing and Reading of Instruments:* Not only are the instruments placed five feet above the substrate, but that substrate may be anything from the tar and gravel roof-top of a 90-foot building in a metropolis, to the bluegrass lawn of an airport, or the unsodded terrain of a farmer's barnyard. Moreover, the instruments, located as they are, in standard coops, are sheltered from almost every condition to which plants and animals are subjected, *i. e.*, wind, rain, snow, insolation, nocturnal radiation to the sky, other plants and animals, and the character of the substrate or soil. Thornthwaite and Leighly (27) have observed that "the range in mean monthly minimum temperature [may be] as great within five feet of the ground vertically as in a belt 300 miles from north to south at the standard level." In Table III are some minimum temperature data obtained in the Botanical Gardens at The Ohio State University. Data included in the table were obtained in February and March, 1944. Temperatures at the five-foot level were obtained by using a standard Weather Bureau thermometer, housed in a shelter similar to that of the Weather Bureau type. Utilizing a technique employed by Wolfe, Wareham and Scofield (34), temperatures were also obtained with three thermometers at the eight-inch level

TABLE III

COMPARISON OF MINIMUM TEMPERATURES RECORDED BY VARIOUSLY EXPOSED THERMOMETERS IN THE OHIO STATE UNIVERSITY BOTANICAL GARDEN WITH THOSE OF NEARBY WEATHER BUREAU STATIONS

1944	Exposed, face up	In therm. holder	Beneath board	Standard shelter	Col's, O., W. Bureau	O. S. U. W. Bureau
Feb. 20	5.0	8.0	14.0	14.0	25	23
Feb. 21	12.0	13.0	19.0	21.5	26	27
Feb. 22	27.5	31.0	29.0	34.0	38	38
Feb. 23	34.5	35.5	35.5	36.5	37	38
Feb. 24	20.5	23.0	29.0	27.0	37	35
Feb. 25	16.0	18.0	22.0	23.5	35	31
Feb. 26	42.0	40.5	43.0	43.5	48	44
Feb. 27	32.0	34.5	37.5	39.5	37	41
Feb. 28	32.0	32.0	33.5	33.5	31	34
Mar. 1	21.0	21.0	23.5	22.5	24	25
Mar. 2	3.0	6.0	12.5	12.5	22	20
Mar. 3	....	19.0	23.5	22.5	32	31
Mar. 5	17.0	15.5	18.0	16.5	18	19

TABLE IV

DISTRIBUTION, ACCORDING TO AMOUNT, OF 415 CONSECUTIVE RAINFALLS OF .05 TO .37 INCHES, AT LANCASTER, OHIO

Amount	Number	Amount	Number	Amount	Number
.05	34	.16	11	.27	13
.06	8	.17	4	.28	4
.07	3	.18	13	.29	4
.08	15	.19	12	.30	27
.09	8	.20	21	.31	3
.10	27	.21	14	.32	15
.11	5	.22	9	.33	7
.12	17	.23	7	.34	8
.13	9	.24	8	.35	24
.14	4	.25	28	.36	11
.15	30	.26	12	.37	5

TABLE V

DISTRIBUTION OF DAILY MINIMUM TEMPERATURES BETWEEN 28° F. AND 36° F. AT LANCASTER, OHIO, OVER A 42-YEAR PERIOD (OCTOBER–APRIL)

MONTH	TEMPERATURE °F.									
	28°	29°	30°	31°	32°	33°	34°	35°	36°	Total
October	17	22	29	36	33	40	43	52	55	327
November	54	60	66	44	61	63	50	55	49	502
December	59	47	48	46	65	31	24	45	18	383
January	55	38	60	24	44	29	46	30	26	352
February	42	30	51	35	59	31	31	35	18	332
March	39	65	74	54	72	40	36	45	28	453
April	27	34	51	39	46	42	49	56	37	381
Total	293	296	379	278	380	276	279	318	231	2730
Percent	10.7	10.8	13.8	10.2	13.9	10.1	10.2	11.6	8.4	99.7

above a blue-grass sod. One thermometer was placed face-up, on a platform constructed of redwood; another was attached below the platform; another was placed in a holder described by the above writers, at the edge of the platform (Fig. 2). Temperatures recorded at the Columbus Weather Bureau and the cooperative station at the Ohio State University are included in the table. From these data it is obvious that it is not to be assumed that minimum garden temperatures are similar to temperatures recorded by the Weather Bureau or its cooperative station. On cloudy or rainy nights, the minimum temperatures may vary only a few degrees, but when there is much radiation to the open sky, differences may amount to as much as 12° F., even in the seclusion of standard shelters. Instruments not so sheltered show even greater differences and further experiments may show these figures to be most applicable to indicate the temperature conditions to which the plants are subjected.

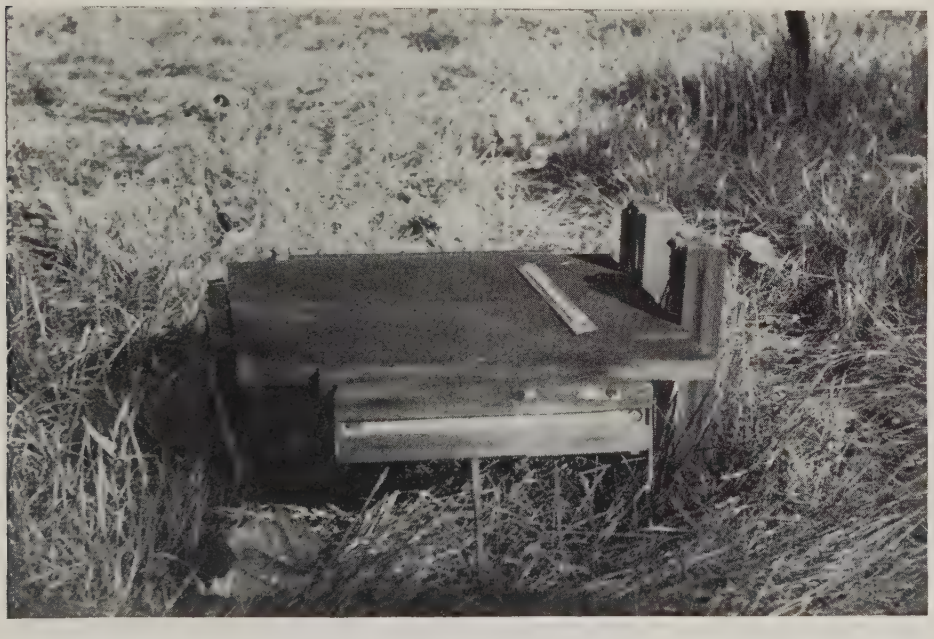

FIG. 2. Photograph of the platform to which variously exposed thermometers were attached to obtain air temperatures at the eight-inch level over a bluegrass sod. Photo by A. Hyder.

The effectiveness of the Weather Bureau set-up in the United States is in great part made possible through the cooperation of 5,000 or more voluntary observers. There are certain features of this system, however, which frequently are sources of slight error. The change of location of the cooperative stations, sometimes entailing significant changes in elevations; lack of uniformity in hours of observation, and breaks in the continuity of the records when the observers retire, are ill, or go on vacation, make certain comparisons of data difficult. Moreover, the data presented in Tables IV and V indicate that the readings may not be exact. All of these, however, may have but little effect on data desirable to the Weather Bureau, nor are they a source of serious error in the compilation of macro-climatic data.

2. *Modification of Observers' Data.* A study of the original records (18) of Ohio cooperative observers on file at the Columbus Weather Bureau, indicates

that some of the observations recorded by the cooperators are subject to modification by their supervisors at the main office. This often leads to false analysis of factors ecologically significant, especially with regard to temperature phenomena.

For example, on the morning of June 23, 1918, at Lancaster, Ohio, the observer recorded a minimum temperature of 40° F., and accompanied the record with a written statement, "Killing frost," adding: "Considerable damage to corn and tender vegetables." The published record (3), however, states that the final spring frost for Lancaster in 1918 was on April 14, 70 days earlier. Moreover, the last "freeze"[4] was recorded on April 25, eleven days after the last official frost. Perhaps no frost occurred the morning of April 25, but it seems unlikely, although entirely possible if surface temperatures were above 32° F. Further study of the Ohio record reveals that this modification is not an uncommon occurrence. (Table VI.)

TABLE VI

LENGTHS OF FROST-FREE PERIODS AT LANCASTER, OHIO, FOR SELECTED YEARS, BASED ON THREE DIFFERENT CRITERIA

Year	Weather Bureau			Observer			32° F. Temp.		
	Last Spring	First Fall	Length in Days	Last Spring	First Fall	Length in Days	Last Sub 32° Spring	First Sub 32° Fall	Length in Days
'05	4/24	10/23	182	None	10/23	.....	4/24	10/13	172
'18	4/14	11/2	202	6/23	9/22	91	4/25	11/2	191
'21	4/18	10/13	178	5/1	None	.....	4/8	10/13	188
'23	4/26	10/5	162	None	9/14	.....	5/9	9/16	130
'26	4/27	11/1	188	None	10/7	.....	5/11	10/7	149
'27	4/24	11/6	206	None	9/21	.....	5/1	9/21	143
'29	5/8	10/18	163	None	10/18	.....	5/8	9/19	134
'32	5/3	10/22	172	5/3	10/22	172	5/3	10/14	164
'35	5/1	10/5	157	None	9/30	.....	5/1	9/30	152
'36	4/25	10/28	186	None	10/28	.....	4/25	10/3	161
'37	5/11	10/14	156	None	10/8	.....	4/12	9/18	159
'38	5/13	10/28	168	5/12	10/28	169	5/13	10/7	147
'39	5/4	10/15	164	5/1	10/15	167	5/4	10/13	162
'40	5/5	10/17	165	5/5	10/17	165	5/5	10/9	157
'41	5/25	10/29	157	None	10/29	.....	5/25	10/11	139

Calculation of the length of the frost free period is subject to additional errors because observers may not report frosts when they do occur. Then the officials use the last 32° F. temperature in spring and the first in the fall, but as indicated in Table VI, may also do so whether or not the observer reports frost. The use of two criteria in determining the frost free period leads to some inaccuracy, although as far as macroclimate is concerned, the error may be insignificant. However, whether the frost free period in 1918 at Lancaster was 91, 191 or 202 days, is difficult to determine.

3. *Methods of Compiling and Incompleteness of Data:* The Weather Bureau records have definite limitations as a measure of ecological factors because of the incompleteness of certain observations. When light is measured, it is usually in terms of total hours of sunshine; relative humidity data are reported only three times daily; persistence of snow cover data are fragmentary or lacking; wind

[4]The term "freeze" is used by the Weather Bureau to refer to conditions when the temperature inside the standard shelter is 32° F. or lower. Frost may be recorded when the temperature inside the shelter is as high as 51 F. (Bowling Green, May 12, 1898. (18)). At Lancaster, O., however, the 50-year average date of the first fall frost is Oct. 15 and the average date of the first fall freeze falls six days earlier.

velocities are either not measured or if so, the data are not applicable to ecological problems. It is not uncommon in Hocking County, Ohio, for winds of gale velocities to roar through the pine forests on the uplands, yet on the forest floor of the lower valley, the leaves of plants in the herbaceous layer do not move perceptibly. No satisfactory method of measuring evaporation has ever been developed; precipitation in the form of dew and frost is not measured. Soil temperature and depth of freezing data are lacking and fragmentary.

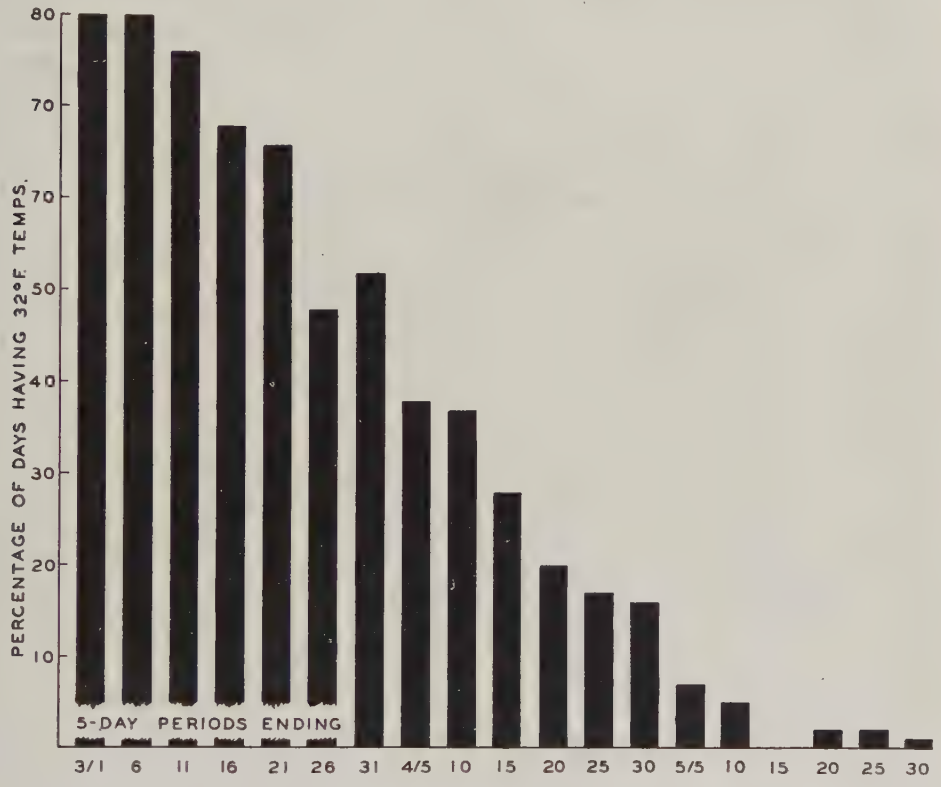

FIG. 3. Frost probabilities for successive five-day periods in spring at Lancaster, Ohio, based on 25-year records from 1910.

Largely because the Weather Bureau data are compiled on a monthly rather than seasonal basis, ecologists publish these data as though each calendar month itself is an ecological factor. Table VII shows how misleading temperature data can be when presented on a monthly basis.

TABLE VII

AVERAGE AND EXTREME TEMPERATURES (°F.) FOR FIVE-DAY PERIODS AT LANCASTER, OHIO, 1910–1935

APRIL	1–5	6–10	11–15	16–20	21–25	26–30	1–30
25 year Average.....	48.6	49.4	50.7	52.9	52.7	53.9	51.3
25 year avg. maximum.	60.4	60.9	62.7	64.5	64.6	65.6	63.1
25 year avg. minimum.	36.9	37.9	39.0	40.9	41.1	41.9	39.6
All time maximum[a]....	83.0	86.0	89.0	88.0	89.0	92.0	92.0
All time minimum[a]....	9.0	19.0	22.0	19.0	21.0	23.0	9.0

[a] 1895–1943.

This is further emphasized when considering probability of frost damage. Figure 3 is based on the frequency of spring frosts during five-day periods over a 25-year span, at Lancaster, Ohio. The percentages indicate the probability of frost during these short periods, from February 26 to May 30.

Although of lesser importance to the ecologist than to the agriculturist, the sub-division of the various states into climatic divisions appears in many cases not to have been done on either a climatic, biotic, or physiographic basis or a combination of the three. Ohio, for example, is divided into "northern," "middle"

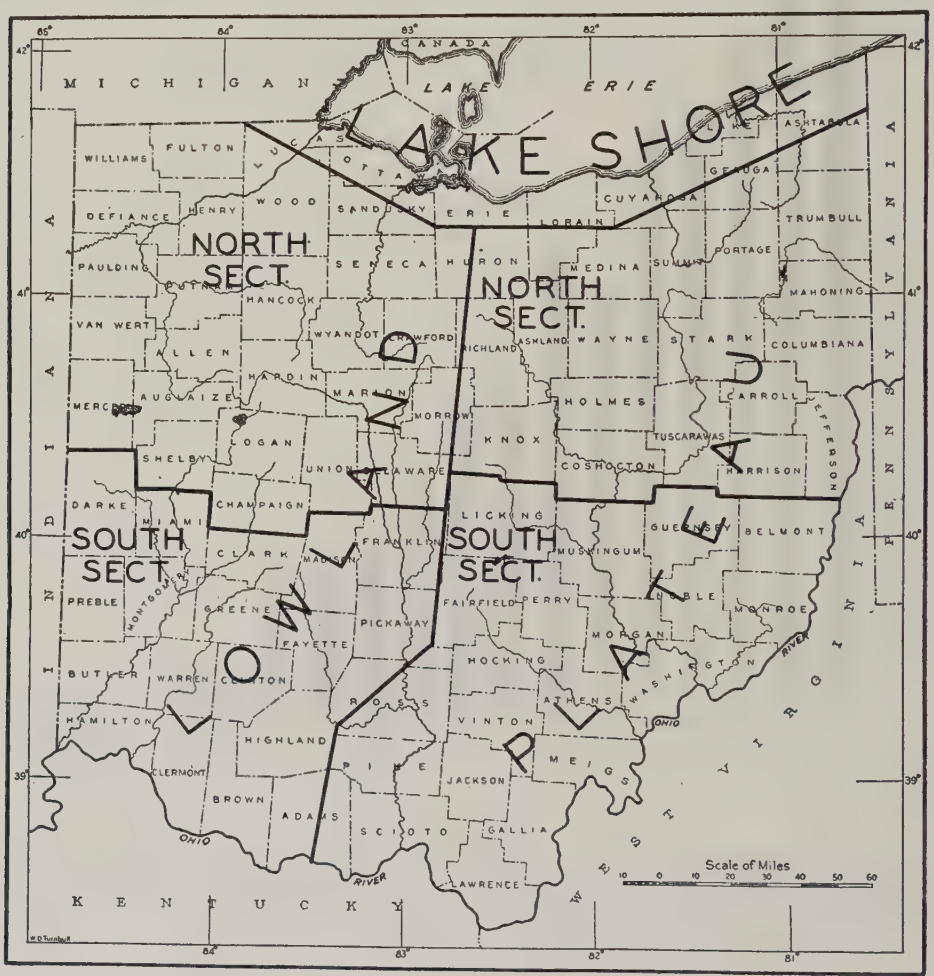

FIG. 4. Suggested subdivision of Ohio for climatic comparisons. This takes into account the effects of the plateau and lake on climate, which physiographic features overshadow the effects of latitude. In western Ohio the influence of physiography is less marked.

and "southern" divisions, apparently on what may be considered a doubtful assumption, stated by Fisher (7) that "probably the greatest variations in the climate [of Ohio] are those incident to latitude." A more desirable subdivision, which would lead to better comparisons, is suggested in Fig. 4.

This analysis of Weather Bureau data, as used by ecologists, is in no way a reflection on the work of the Bureau and its thousands of cooperative observers.

They have contributed abundantly to one phase of human knowledge. Rather, the data seem to emphasize the need for a different approach to climatic and weather problems as related to agriculture, forestry, ecology and conservation. "Knowledge of human climate," as Geiger (9) remarks, "has now reached a stage of tentative finality." With the broad generalizations developed, they stand as a basis from which to work out the variations and trends in the many habitats located within large areas. This is the province of microclimatology.

SOME PROBLEMS OF MICROCLIMATOLOGY

Microclimatology, or ecological meteorology, however, is confronted with a number of major problems which will have to be solved before satisfactory data can be obtained and adequate correlations made with carefully observed biotic phenomena. Four of the principal problems are mentioned below.

1. *Instrumentation.*—The development of new instruments and the modification of old ones is necessary to meet the difficulties connected with the measurement of factors in the habitats. Many present instruments were constructed for laboratory use, or for use in protected shelters, or have been placed where they could be frequently and easily adjusted.

2. *Experimentation in Methods.*—Much needs to be done in determining what methods most accurately measure ecological factors in the field. In a leading ecology textbook there is the remark: "With the aid of a thermometer, the measurement of temperature is an easy task" (31). The reading of a thermometer is easy, but "of what is that reading the temperature?" is another question indeed.

3. *Accumulation of Phenological Data.*—Published records of observations of plants and animals in the habitats where the factors are being measured are notable by their absence. Even though it be assumed that Weather Bureau data reflect actual habitat conditions for a given region, observations relative to date of planting, beginning of growth, time of germination, period of greatest vegetative growth, time of flowering, time of maturation of fruit, quality and quantity of the crop are almost totally lacking or exceedingly fragmentary or unreliable.

4. *Facilities for a Long-Time Research Program.*—Thornthwaite and Leighly (27) have outlined a research program which would attempt to meet these problems as well as many others. They suggest that such a program be connected with a large university, so that space, diverse facilities of the various related science departments, and manpower could be available. This appears to be an excellent method of approaching the present and future problems of ecological meteorology.

SUMMARY

1. Weather Bureau meteorological data have been the basis for the development of climatic concepts, and evidence of climatic trends over large biotic areas such as desert, prairie and forest.

2. Weather Bureau records have been re-published extensively by ecologists in conjunction with ecological studies, but correlation of biotic phenomena with the climatic data has not been explained or demonstrated.

3. There is wide variation between macroclimates as determined from Weather Bureau data and the actual (microclimates) to which biotic communities are subjected and by which they are limited.

4. Weather Bureau data are not applicable when explaining such biotic phenomena as growth, reproduction, succession and death of plants and animals in various habitats of a region.

5. There appears to be an urgent need for direct measurements of microclimatic phenomena in the analysis of many problems of agriculture, forestry, ecology and conservation.

6. Further advances in a knowledge of microclimates depend upon the develop-

ment of new instruments and methods, the accumulation of precise phenological data in the habitats or fields where the factors are being measured, and the establishment of facilities for a long-time research program.

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STUDIES IN HUMAN INHERITANCE XXVII

The Inheritance of the Shape of the Sella Turcica[1]

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The shape of the sella turcica as seen in X-ray pictures varies from circular through oval to flat or saucer-like. Almost nothing is known as to the possible genetic basis for such differences in shape. Dillon and Gourevitch (1934, 1936) observed the variation in sella form in 26 pairs of twins, 14 fraternal and 12 identical, and concluded that these variations were chiefly influenced by genetic factors. Maguid (cited by Dillon and Gourevitch) compared four pairs of identical twins with four pairs of fraternal twins, and found striking similarities in sella shape in the identicals and marked differences between the members of the pairs in the fraternal group.

Fig. 1. Diagrammatic representation of the three shapes of sella turcicas. I, round; II, oval; III, flat.

In the course of a genetic investigation of the variation of pneumatization of mastoids, configuration of sinuses, and form of sellas, we have taken standard X-ray pictures of parents and children. In a preceding paper (Snyder and Blank, 1944) we presented evidence that bridged sella is inherited on the basis of a dominant gene substitution. It is the purpose of this paper to present the results of our analysis of sella shape based on X-ray pictures of 100 individuals belonging to 24 families.

Knowledge of the possible genetic factors underlying sella shape may be of practical as well as theoretical importance, since the size and shape of the pituitary gland is obviously proportional to the form of the sella turcica which houses it. The secretory function of the gland may or may not be related to its size and shape, but the genetic study of such conditions as Froehlich's disease, Simmond's disease, adiposity and short stature requires a better knowledge of variation in the sella turcica than we now possess.

The X-ray pictures were taken in the standard position for lateral radiography of the sella turcica. The work was done at St. Francis Hospital, Columbus, Ohio. The distance was in all cases the same and was sufficiently great to avoid distortion.

[1]The authors gratefully acknowledge the receipt of a grant from the Committee on Human Heredity of the National Research Council, which made possible these studies.

[2]Chairman, Department of Zoology and Entomology, and Professor of Medical Genetics, Department of Medicine, The Ohio State University.

[3]Medical Director, Bureau of Human Heredity, London, England; Guest Investigator, The Ohio State University.

FIG. 2. X-ray photographs of the three types of sella turcicas. Upper, round; middle, oval; lower, flat.

The sellas were measured in two dimensions: saggittal, the maximal anterior-posterior distance, and vertical, the distance from the middle of the base to a line connecting the tips of the anterior and posterior clinoid processes (Fig. 1). It was found that the ratios between width and height fell into three rather sharply defined groups with very little grading from one to the other (Fig. 2). The three groups were as follows:

I circular; width to height being about 1 : 1.
II oval; width to height being about 1.5 : 1.
III flat; width to height being about 2 : 1.

The proportions of the three groups in our one hundred cases were as follows: type I, 41 per cent, type II, 50 per cent, and type III, 9 per cent. These proportions differ somewhat from those reported by Koehler (1928) on 500 X-ray pictures of normal European individuals, where the figures were type I, 24.4 per cent, type II, 58.4 per cent, and type III, 17.2 per cent. It would not be surprising to find racial and group differences in sella shape as have been found in skulls.

The types of mating in our material and the offspring from these types are as follows:

Mating Type	No. of Families	Offspring		
		I	II	III
I x I	3	6	.....	.....
I x II	11	12	11	1
I x III	1	4	.....	.....
II x II	5	.....	10	.....
II x III	4	.....	5	3
III x III	.....	.....	.....	.....

It is clear that there is a correlation between types of parents and types of offspring. However, with the small number of individuals a trustworthy estimate of the association can not be obtained. The data are highly suggestive, and indicate the action of Mendelian factors in the production of sella shape. The collection of further data seems justified, and it is hoped that these studies, interrupted by the exigencies of the war, may be continued when the opportunity again presents itself.

Unusually small sellas were encountered in two families. In one family the mother and both of her sons showed the trait; in the other, the father and one of two sons had the small sellas.

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THE SIMILARITY EXISTING BETWEEN SOME ALGAE AND SOME POLLENS WITH A FURTHER NOTE CONCERNING PHYTOMORULA REGULARIS KOFOID[1]

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Herbert F. Copeland (1937) pointed out the similarities existing between certain Mimosoideae pollen and Kofoids algal genus Phytomorula. This paper, in Madroño, appears not to have had the wide circulation among algologists which it deserved.

To anyone who has seen pollen from such species of Acacia as *A. longifolia*, *A. baileyana*, or *A. verticilata*, there can be no doubt as to the accuracy of Copeland's conclusions. A discrepancy which he mentions, however, does exist between the two published figures of *Phytomorula*. That by Kofoid (1914) shows a small dome-like protuberance on each cell, while Smith's figure (1933) shows a larger, broad protuberance. Copeland was not able to explain this discrepancy, although he suspected that the shape of the protuberance was dependent upon the degree of exposure to which the pollen cluster had been subjected. The present work appears to verify these suspicions.

The writer, in organizing a reference collection of pollen in connection with a study of fossil and subfossil algae of Ohio Bogs, noted the similarities as well as the discrepancies existing between Acacia pollens and the figures of Phytomorula. In an attempt to find a suitable method of preparing pollens for study, the reasons for these differences became evident. A pollen cluster of Acacia when taken directly from the flower and shown in Fig. 1c, shows the broad protuberance on the outer face of each cell. When such a cluster is treated with various mounting media, a distinct shrinkage is evident, resulting in small dome-like protuberances as figured by Kofoid, Fig. 1a. If the shrinkage is controlled by varying the concentration of the media, clusters will be found in which some of the cells show the small dome-like protuberance, while others exhibit no sign of shrinkage, Fig. 1b. Figure 1d is a copy of Smith's figure of Phytomorula.

Such differences in the contour of cells of Acacia pollen clusters therefore appear to be due to varying periods of exposure before collection. The discovery of the true nature of Phytomorula by Copeland is an excellent example of the implications which may be evident to the algologist and non-algologist alike.

With the recent advance in the study of fossil pollen and fossil algae in peat deposits, the need for a reciprocal knowledge of their respective fields by the pollen analyst and algologist is evident. As both pollen and algae occur interspersed in the same deposits, it is sometimes very difficult to identify them with any degree of certainty unless they or their near relatives have been previously encountered in living condition.

The foregoing example is merely a case where the algologist was led into committing an error because of a lack of information concerning pollen structure. If we look at the other side of the fence, we find possibilities of pollen workers committing the same kind of errors. If there is so great a resemblance in one direction, then there may be a possibility of the situation being reversed. In substantiation of this, there is a genus of the unicellular algae, *Trochiscia*, the species of which are identified entirely on wall characters. Species having reticulate,

[1]Paper from the Department of Botany, The Ohio State University. No. 481.

spiny, or otherwise sculptured walls might easily be mistaken for pollens. Also that certain pollens might be assigned to this genus by the inexperienced algologist. Another error, and one which I feel may have been committed in some instances, is the identification of the cysts of certain species of *Trachelomonas* as grass pollens. This genus, a relative of Euglena, is characterized by having the individual surrounded by a silicious cyst with one pore. A study of the cyst, however, will readily distinguish it from pollens.

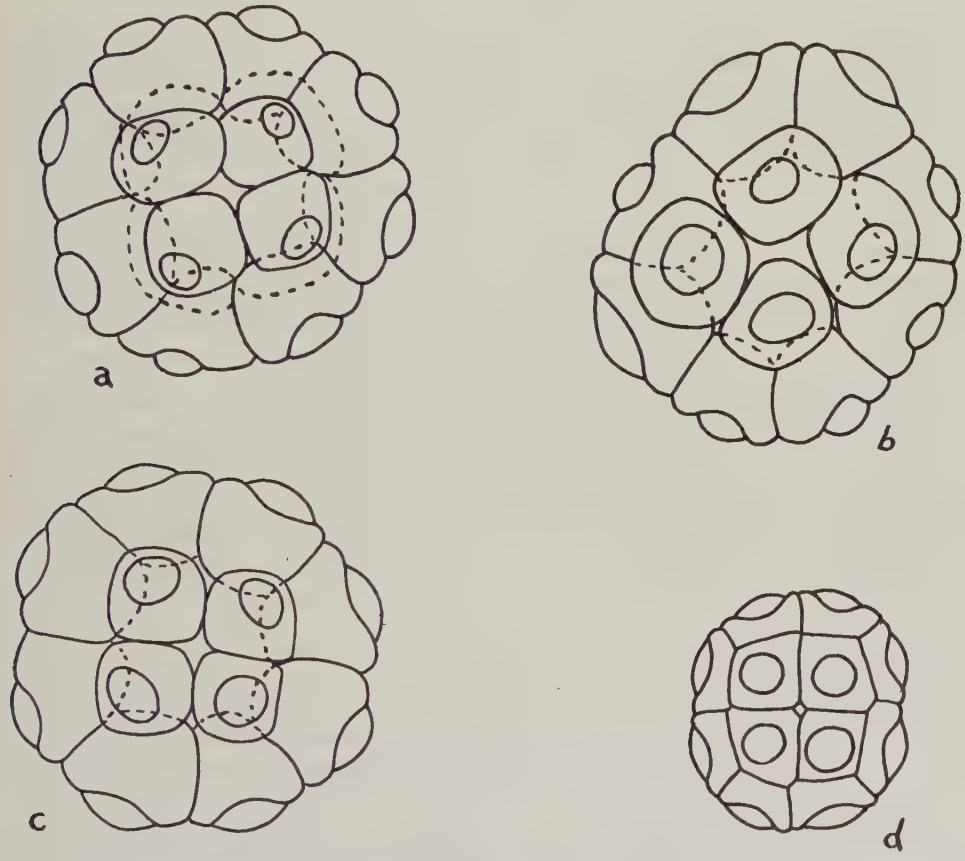

FIG. 1. a—Kofoid's figure of *Phytomorula regularis;* b—Pollen cluster of *Acacia longifolia* with some cells showing marginal shrinkage; c—Fresh pollen cluster of *A. longifolia* with no marginal shrinkage; d—Smith's figure of *Phytomorula regularis* Kofoid.

In order to eliminate the possibility of error, the algologist, and especially the one interested in fossil algae, should familiarize himself with as many pollens as possible. Likewise, the pollen analyst should be familiar at least with the various classes of algae.

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NOTES AND RECORDS OF LEPIDOPTERA IN OHIO[1]

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Occasionally southern species of Lepidoptera are found in Southeastern Ohio. The following are records of southern species that have been taken and which seldom reach areas as far north as Ohio.

Erebus odora Linn.: Jackson, Ohio. 1 ♀—19–V–'37, at filling station; John H. Hughes, Collector.

Errinyis ello Linn.: Athens, Ohio. 1♂—10–VIII–'44, resting on tree trunk; Frederick W. Stehr, Collector.

Errinyis obscura Fabr.: Athens, Ohio. 1 ♀—20–IX–'31, in light trap; Wm. C. Stehr, Collector.

Errinyis domingonis Butler: 1 ♀—26–X–'38, on bridge railing; Thatcher Hart, Collector.

From observations on *Asterocampa celtis* (B. & L.) and *Asterocampa clyton* (B. & L.) during the past fifteen years, it appears that in general these species frequent areas of low illumination during the daytime hours. There is some evidence that they may be somewhat crepuscular or even nocturnal in some of their activities. The following records seem to substantiate these conclusions.

Of forty specimens of *Asterocampa celtis* (B. & L.) taken between 7:00 A. M. and 7:00 P. M. in southeastern Ohio, only two were taken in open sunny areas. All of the others were taken along the edge of woods in rather poorly lighted ravines in Athens, Meigs, Hocking, Jackson, Vinton and Lawrence Counties, Ohio. On July 19, 1938, fourteen specimens of this species were taken along a deep ravine in Torreya State Park, Florida. None were seen in the more open, better lighted areas of the Park.

Of thirty-two specimens of *Asterocampa clyton* (B. & L.) taken during the same period, none were taken in open country. All of them were found in shaded areas.

These species have also been taken occasionally at night. Nocturnal records are herewith presented.

Nocturnal Records of *Asterocampa celtis* (B. & L.).

Athens, Ohio: 1♂, 27–VI–'41, at porch light, 9:45 P. M. Wm. C. Stehr, Coll.
1 ♀, 10–VI–'37, sugaring on tree trunk, 10:00 P. M. Wm. C. Stehr, Coll.
Cherokee, N.C.: 1 ♂, 26–VI–'38, at filling station light, 9:30 P. M. Wm. C. Stehr, Coll.

Nocturnal Records of *Asterocampa clyton* (B. & L.).

Athens, Ohio: 1 ♂, 4–VII–'31, in light trap. Wm. C. Stehr, Coll.
1 ♀, 3–IX–'33, in light trap. Wm. C. Stehr, Coll.
1 ♂, 6–IX–'33, in light trap. Wm. C. Stehr, Coll.
1 ♂, 1–VII–'32, at light sheet, 10:00 P. M. Wm. C. Stehr, Coll.
1 ♀, 29–VII–'32, at sugar, 11:00 P. M. Wm. C. Stehr, Coll.

In four years, 1931–'34 inclusive, during which a light trap was operated every night from April 15 to October 30, no other species of butterfly was ever taken. Neither were any others ever observed at light sheets, outdoor electric lights or on sugar.

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[1]Paper No. 24, from the Department of Zoology, Ohio University, Athens, Ohio.

A SYSTEMATIC STUDY OF THE MAIN ARTERIES IN THE REGION OF THE HEART—AVES XXI.

Passeriformes—Paridae. Part 1[1]

FRED H. GLENNY[2]

As Garrod (1873) has already pointed out, the Passeriformes are characteristically "aves laevo-carotidinae," but as the present writer has shown in several recent papers, in certain orders of birds (Glenny, 1940, 1942 and 1943a, and Glenny, unpublished papers) the arrangement of the internal carotid arteries cannot be entirely utilized as an ordinal character. Furthermore, as has been shown in other recent studies (Glenny, 1943b, 1943a, and 1944) there may be characteristic family variations of the basic ordinal arterial arrangement-pattern within an order—aside from certain minor individual or specific differences—which may be used in gross anatomical and perhaps in phylogenetic studies.

It is of particular interest, therefore, to determine, in so far as possible, the family arrangement-patterns of the main arteries in the neck and thorax of the Passeriformes. The present study is limited to a consideration of the arterial arrangements of four species of the Paridae.

MATERIALS

The species used in this study were collected by Professor Tsen-Hwang Shaw, Fan Memorial Institute of Biology, Peiping, China; the Division of Ornithology, Cleveland Museum of Natural History; and the author.

Single specimens of *Parus major artatus* (Thayer & Bangs) and *Parus palustris hellmayri* (Bianchi), and two specimens of both *Parus atricapillus* L. and *Baeolophus bicolor* L. were dissected and diagrams prepared.

The following observations are based upon the information obtained in the study of the above specimens.

OBSERVATIONS

The basic family arterial arrangement-pattern for the species studied is characteristic.

The aortic root (1) arises in the left ventricle, passes anteriorly and diagonally to the right for a short distance before bifurcating to form the innominate arteries (2). The functional (right) systemic (4th aortic) arch (3) arises from the right innominate artery near its base. The systemic arch connects directly with the right radix aortae (4) which passes posteriorly and diagonally from the right toward the centre where it becomes the dorsal aorta (7). The ligamentum aortae (5) remains as an extremely small ligament and the proximal attachment to the pulmonary artery (6) may atrophy completely.

The innominate arteries pass anteriorly and diagonally to the right and left and then divide to form the subclavian (9) and common carotid (8) arteries. The subclavian artery sends off the intercostal (10)—from the posterior face—, coracoid major (11)—from the ventral face—, axillary (12)—from the anterior face—, and two pectoral (13) arteries.

The common carotids give rise to a short thyroid artery (21) before giving rise to the superficial cervical (14), vertebral (15), and internal carotid (18 and 19) arteries. The ductus shawi (16) arises from the vertebral artery, near its origin

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[1]Contributions from the Department of Zoology, University of Toronto.

[2]Formerly Assistant, Department of Zoology, University of Toronto; now on active service with the U. S. Army Medical Department.

from the common carotid artery, and sends off the syringo-tracheal branches (17) before passing posteriorly to supply the oesophagus, bronchi, and connective tissues in the region of the heart.

The superficial cervical arteries supply the muscles, glands, and accessory tissues of the neck; the right vessel also sends branches to the oesophagus. The right internal carotid becomes functionally modified as the ascending-oesophageal artery (19), while the left internal carotid (trunk) artery (18) alone enters the hypapophysial canal to carry the major cephalic blood supply.

Except in *Baeolophus bicolor*, the scapular arteries arise from the superficial cervical arteries, but in *Baeolophus* the right scapular artery arises from the ascending-oesophageal artery, and the left scapular artery arises from the left vertebral artery or from the left superficial cervical which (in this case) arises from near the base of the left vertebral artery. This may be an individual difference and may vary somewhat in different specimens.

The right ligamentum botalli atrophies completely or fuses entirely with the right radix aortae and is, as a result, entirely lacking.

DISCUSSION

From the above observations it is readily seen that—in so far as the present study is concerned—there is a fundamental and essential similarity in the arrangement of arteries in the neck and thorax of the Paridae. It will be noted further that the species of *Parus* are identical in arrangement, and differ but slightly from *Baeolophus bicolor* in so far as secondary vessels are concerned.

ACKNOWLEDGMENTS

The writer wishes to express his gratitude to Professor Tsen-Hwang Shaw, Fan Memorial Institute of Biology, Peiping, China; Dr. E. Horne Craigie, Department of Zoology, University of Toronto, Toronto, Canada; Dr. Harry C. Oberholser, Cleveland Museum of Natural History, Cleveland, Ohio; and Dr. Alexander Wetmore, United States National Museum, for their help and suggestions during the progress of these studies.

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(Unpublished papers):

(a) A systematic study of the main arteries in the region of the heart—Aves XII. Galliformes, Part 1. (In press.)

(b) A systematic study of the main arteries in the region of the heart—Aves XIII. Ciconiiformes, Part 1. (In press.)

(c) A systematic study of the main arteries in the region of the heart—Aves XVII. Colymbiformes, Part 1. (In press.)

(d) The main arteries in the neck and thorax of five species of Parrots.

EXPLANATION OF FIGURES IN PLATE

1, Aortic root; 2, Innominate arteries; 3, Right systemic arch; 4, Radix aortae; 5, Ligamentum aortae; 6, Pulmonary artery; 7, Dorsal aorta; 8, Common carotid artery; 9, Subclavian artery; 10, Intercostal artery; 11, Coracoid major artery; 12, Axillary artery; 13, Pectoral arteries; 14, Superficial cervical artery; 15, Vertebral artery; 16, Ductus shawi; 17, Syringotracheal arteries; 18, Left internal carotid (trunk) artery; 19, Ascending-oesophageal (right internal carotid) artery; 20, Scapular artery; 21, Thyroid artery.

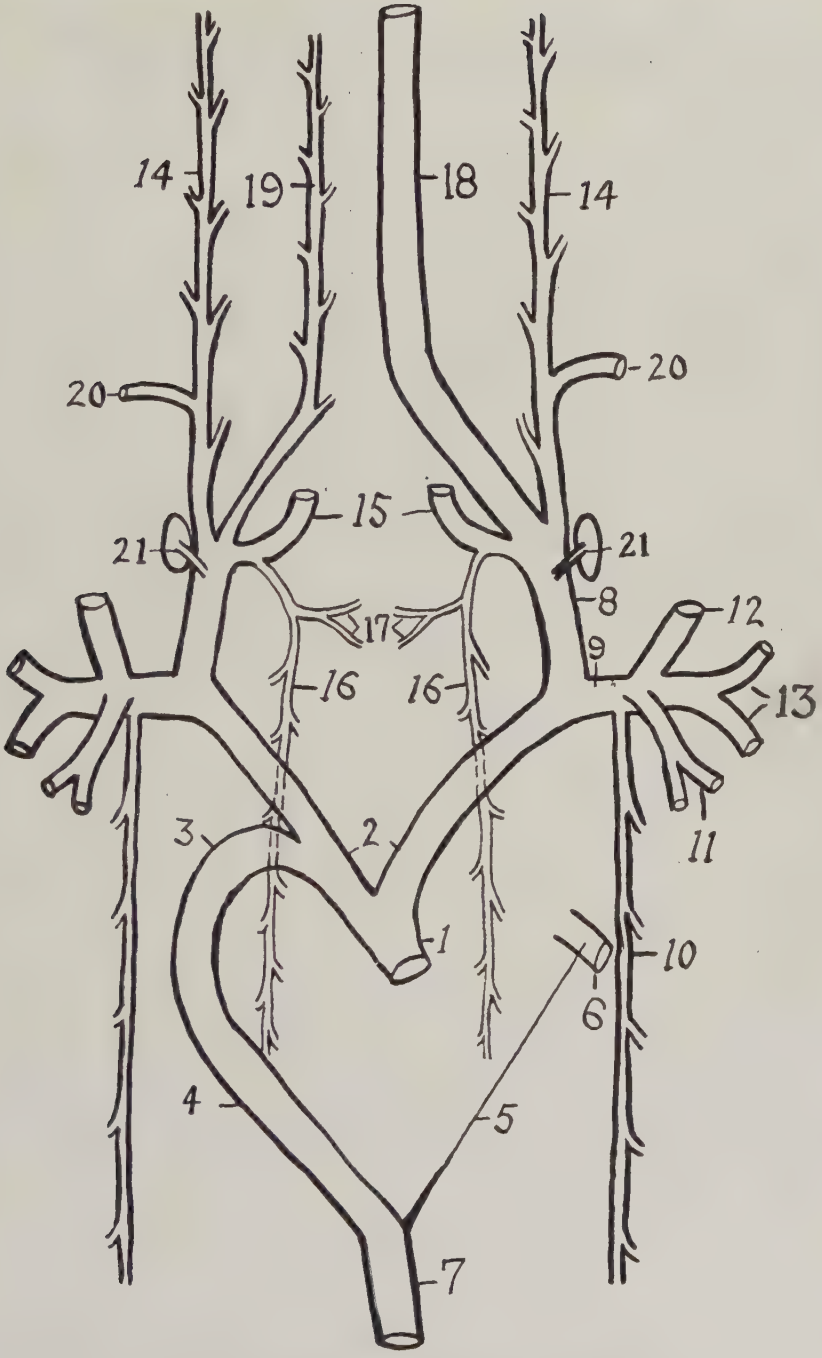


Diagram of the main arteries in the neck and thorax of *Parus palustris hellmayri*. Ventral view.

SOME NEW SPECIES OF CLOANTHANUS (HOMOPTERA-CICADELLIDAE) FROM THE EASTERN UNITED STATES

DWIGHT M. DeLONG,
Department of Zoology and Entomology,
Ohio State University

In 1931 Dr. E. D. Ball[1] established several new genera to include species formerly placed under the European genus Platymetopius. The name Scaphytopius was proposed for one group with *Platymetopius elegans* V. D. as the genotype. Another group, Cloanthanus, was established with *Platymetopius angustatus* Osborn as the type. The species for which six generic names were proposed seem to be very similar and it is doubtful if four generic names will prove to be valid genera. *P. elegans* is, however, different from the other species and it seems logical to retain the genus name Scaphytopius for *elegans*. Since *P. angustatus* is designated as the type of Cloanthanus it has been cited here as the genus name for the larger group of related species. Recent work upon the eastern species of this group, using all the available material, and particularly attempting to identify all of the Illinois specimens has indicated several apparently undescribed species on the basis of external characters and the male genital structures.

Several species have previously been confused and placed under the name *P. acutus* Say. In order to establish all of the species concerned it has been necessary to erect a neotype for that species, since the type has been destroyed.

Cloanthanus acutus (Say)

Jassus acutus Say. Jour. Acad. Nat. Sci. Phil. 6: 306, 1831; Compl. Writ. 2: 382.

A pale to dark brown species with yellow, brown margined, face. Length 4.5 mm.

Vertex produced rather sharply, almost two-thirds as wide between eyes at base as median length.

Color: Brown, vertex with median pale vitta at apex and conspicuous pale vittae on disc. Pronotum dark brown, scutellum tawny. Elytra pale with scattered dark brown irrorations leaving many pale spots and areolar spots. Face yellow, heavily infuscated with brown above the white line and at sides.

Genitalia: Female last ventral segment with posterior margin roundedly produced. Male pygofers one-fourth longer than plates. Styles with apical third abruptly narrowed and produced as slender finger-like processes which curve outwardly. Dorsal portion of aedeagus with a long slender ventral process which is sinuate and tapered to apex where it is slightly enlarged. Ventral paired processes long and narrowed to apex. Pygofer long, narrowed to a blunt, produced apex.

This is the common yellow faced species occurring in southern Illinois and Indiana and is undoubtedly the species which Say described. A neotype is erected at this time in order to establish a definite character for future identification. Neotype collected at Greenwood, Wisconsin, August 19, 1916.

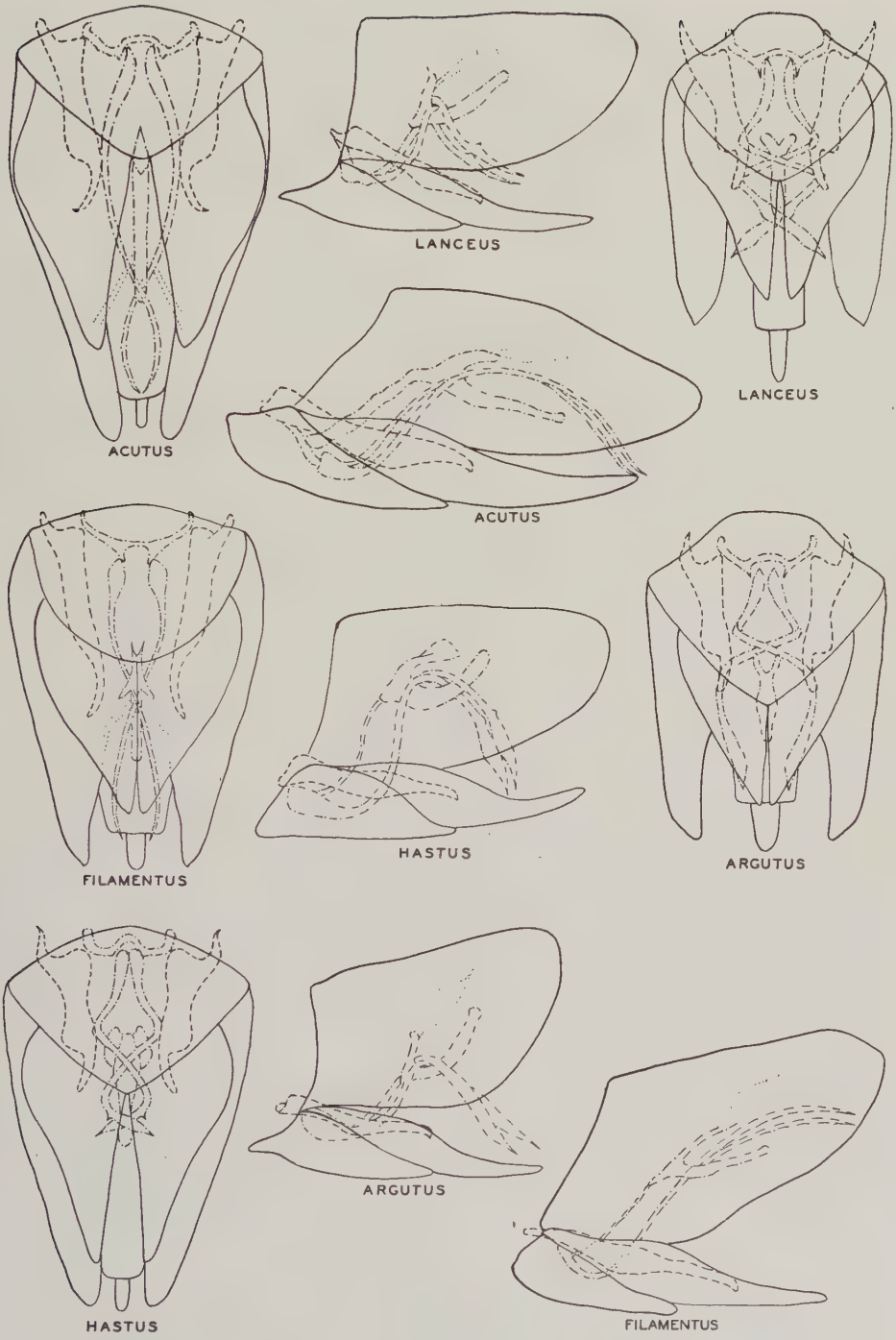
Cloanthanus filamentus n. sp.

Resembling *acutus* in form and general appearance, but paler in color and with a shorter dorsal aedeagus in males and a blunter pygofer. Length 5 mm.

Vertex two-thirds as wide between eyes at base as median length.

Color: Light brown with three pale vittae on apical portion. Pronotum with the usual pale vittae. Apical half of scutellum pale. Elytra rather sparsely irrorate with pale brown so that

[1]Can. Ent., 43: 216–220, 1931.



Ventral and lateral views of male genital structures of species as labelled.

many areolar spots and pale areas are seen throughout the surface. Face yellow with brown margin above.

Genitalia: Female last ventral segment with posterior margin roundedly produced. Male styles narrow, gradually narrowed just beyond middle to narrow curved apical processes which are more than one-third the length of the style. Dorsal portion of aedeagus with an elongated narrow process which is shorter than in *acutus*. Ventral paired processes long, slender, extending almost to apex of pygofer. Pygofer more blunt at apex than *acutus*.

Holotype male and paratype male from Greenville, Pennsylvania, July 14, 1922. Collected by the author.

Types in author's collection.

Cloanthanus tenuis n. sp.

Resembling *acutus* in form and general appearance but with a shorter basally rounded dorsal process of the aedeagus. Length 4.5 mm.

Vertex a little more than half as wide between eyes at base as median length.

Color: Pale brown, vertex with pale longitudinal vittae especially on apical portion of vertex. Pronotum darker on disc, scutellum with apical portion orange yellow. Elytra marked with pale brownish irrorations leaving many pale areas and areolar spots. Face yellow with a brown border above.

Genitalia: Male styles with short finger-like processes at apex which are about one-fifth the length of the styles. Dorsal portion of aedeagus medium in length, narrow and with base sharply curved. Ventral paired processes of aedeagus long and slender, reaching to apex of pygofer.

Holotype male, Capa, South Dakota, August 27, 1919 (Severin). Paratype male, Fish Lake, Utah, September 2, 1930, collected by the author.

Types in author's collection.

Cloanthanus hastus n. sp.

Resembling *acutus* in form and general appearance but with a pale brown face. Length 4.5 mm.

Vertex elongate, sharply angled, decidedly more than half as wide between eyes at base as median length.

Color: Rather dark brown, vertex with median apical vitta and slender elongate lines pale. Pronotum with five longitudinal vittae. Elytra rather heavily irrorate with brown, veins brown. Many pale areas and areolar spots. Face pale brown.

Genitalia: Female last ventral segment roundedly produced on posterior margin. Male plates almost as long as pygofer, gradually narrowed to blunt apices. Style elongate with an abruptly narrowed finger-like process on inner margin of apex which is almost one-third the length of the style. Aedeagus with the dorsal portion rather short and thickened and bluntly pointed at base. Paired ventral processes long and narrow to apical fifth which is widened to form spear-like blades which are pointed at apex and bear a small spine on the upper surface about one-fourth the distance from apex.

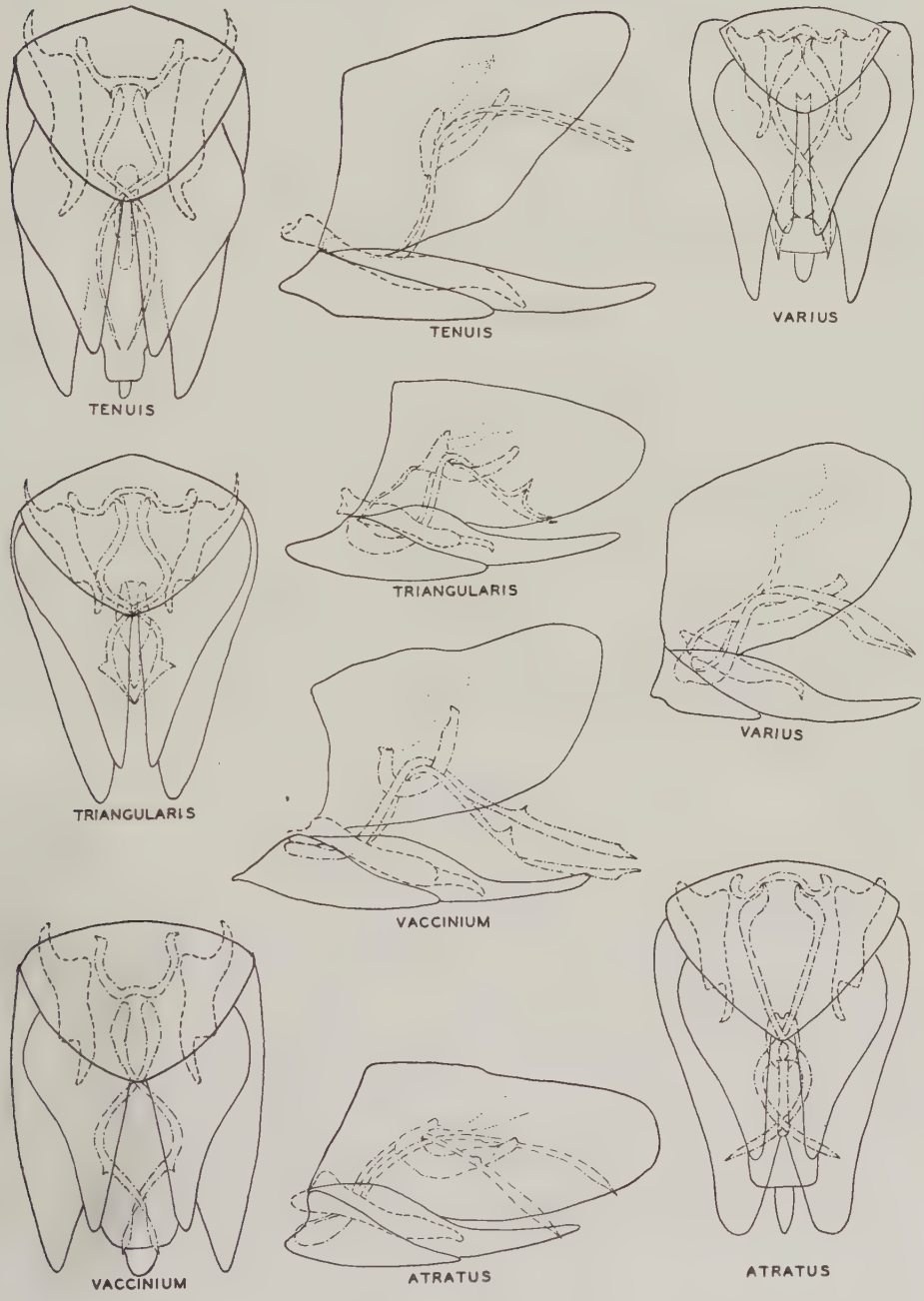
Holotype male, Dixon, Illinois, September 17, 1935; allotype female from Ozark, Illinois, May 18, 1932. Male and female paratypes from same localities and from Cave in Rock, Galena, Centralia, White Pine, Dolson, Mahomet, Des Plaines, Pulaski, Waucanda, Fairfield, Herod, Jeff, Eichorn, Alton, Vienna, and Keithsburg, Illinois; Cranmoor, Wisconsin; Cantwell Cliffs, Ohio; and Neosha, Missouri.

Holotype, allotype and paratypes in Illinois Natural History Survey collection. Paratypes in author's collection.

Cloanthanus argutus n. sp.

In form and general appearance resembling *hastus* but smaller and with distinct male genitalia. Length 4 mm.

Vertex rather sharply angled, a little more than half as wide as median length, one-fourth longer than pronotum.



Ventral and lateral views of male genital structures of species as labelled.

Color: Dark brown with pale markings. Vertex with conspicuous pale longitudinal vittae. Pronotum with several pale punctate spots. Elytra with brown veins and irrorate markings, leaving pale areas throughout and several round pale areolar spots. Face dull yellow below, brown above.

Genitalia: Female last ventral segment roundedly produced on posterior margin. Male plates shorter than pygofer, gradually sloping to bluntly pointed apices. Styles narrowed somewhat at about three-fourths their length, apices rather broad, blunt at apex and produced about one-fourth the length of style. Dorsal portion of style medium in length, a little narrower at apex than base. Ventral paired processes with apical third widened to form a narrow blade which does not bear a spine on dorsal margin. The pygofer is rather broadly rounded at apex.

Holotype male, allotype female and female paratype from Cornelia, Georgia, June 18, 1925. Collected by the author. Type in author's collection.

Cloanthanus lanceus n. sp.

A small sharp headed species resembling *argutus* in general appearance but smaller and with different genitalia. Length 4 mm.

Vertex sharply pointed, almost half as wide between eyes at base as median length.

Color: Vertex pale brownish with longitudinal pale markings. Pronotum dark brown with five pale longitudinal vittae. Scutellum paler, apex pale brown. Elytra finely irrorate with dark brown, only a few pale spots visible and with few areolar spots. Face uniform dull yellow to pale brown without infuscation above.

Genitalia: Female last ventral segment roundedly produced on posterior margin. Male style notched on outer margin at about three-fourths its length, forming a finger-like process which is produced to form the apex of the style. Dorsal portion of aedeagus medium in length with a sharp bend at base. Ventral paired processes curved through the bend in the dorsal portion, their apices broadened to form blade-like apices which extend about one-fourth the length of process and bear a pointed heel on upper, inner angle of blade.

Holotype male, allotype female and male and female paratypes collected at Birmingham, Alabama, June 16, 1925, by the author.

Types in author's collection.

Cloanthanus varius n. sp.

Resembling *magdalensis* in form but with vertex white mottled with brown and with distinct male aedeagus. Length 4 mm.

Vertex short, blunt, more than three-fourths as wide between eyes at base as median length.

Color: Vertex white with a marginal bar either side at apex and longitudinal brown vittae at apex and between eyes, giving it a transversely banded appearance. Pronotum dark brown. Scutellum tawny with white spots on median portion. Elytra brown, heavily irrorate with dark brown, mottled appearance of lighter coloration and paler areolar spots. Face heavily irrorate with brown.

Genitalia: Female last ventral segment roundedly produced on posterior margin. Male pygofer decidedly longer than plates. The apical one-third of style narrowed to a slender curved finger-like process. Dorsal portion of aedeagus rather long, constricted just before apex. Ventral paired processes broadened on apical fourth to form a blade. Spine on upper margin about one-third the distance from apex and bent inwardly on dorsal margin.

Holotype male, allotype female and male and female paratypes from Monticello, Illinois, June 11, 1934 (Frison and DeLong). Paratype females, White Pine State Park, July 12, 1934 (DeLong and Ross), Starved Rock, July 14, 1932 (Dozier and Park), Dixon Springs, July 9, 1935 (DeLong and Ross), Marshall, September 27, 1935 (Frison and Ross), Elizabethtown, Illinois, June 25, 1932 (Ross, Dozier and Park).

Holotype, allotype and paratypes in Illinois Natural History Survey collection. Paratypes in author's collection.

Cloanthanus vaccinium n. sp.

A short broad-headed species resembling *magdalensis* but with distinct genitalia. Length 4.5 mm.

Vertex short, three-fourths as wide between eyes at base as median length.

Color: Vertex brown, appearing banded with conspicuous elongate white vittae at middle of apex and base. Elytra dull brown with scattered darker brown irrorations. Veins brown. White areolar spots along commissure of clavus and in base of apical and apex of anteapical cells. Face heavily irrorate with brown.

Genitalia: Female last ventral segment with posterior margin roundedly produced. Male styles abruptly narrowed at two-thirds their length, apical third finger-like and curving slightly outwardly. Dorsal portion of aedeagus broadly curved at base, narrowed on anterior margin at apex. Ventral paired processes with apical third broadened into blade-like portions. A large conspicuous spine on dorsal margin more than one-third the distance from apex.

Holotype male, allotype female and male and female paratypes from Antioch, Illinois, August 24, 1935. Female paratypes from Volo, Grand Detour, and Dixon, Illinois.

Holotype, allotype and paratypes in Illinois Natural History Survey collection. Paratypes in author's collection.

Cloanthanus atratus n. sp.

Form and general appearance of *vaccinium* but with narrower aedeagus blades. Length 4 mm.

Vertex about three-fourths as wide at base as median length.

Color: Brown, vertex with few pale markings, a short apical median conspicuous vitta. Elytra brown with brown veins and scattered brown irrorations, leaving many pale areas and white areolar spots. Face heavily irrorate with brown.

Genitalia: Male plates decidedly shorter than pygofer. Styles with short narrow apical processes which are about one-fourth the length of style. Dorsal portion of aedeagus broad at base, narrowed on apical fourth. Ventral paired processes with apical third widened to form narrow blades. A small spine is on dorsal margin more than one-third the distance from apex.

Holotype male and paratype male collected at Castle Rock, Oregon, Illinois, June 30, 1935 (DeLong and Ross).

Types in Illinois Natural History Survey collection.

Cloanthanus triangularis n. sp.

Resembling *magdalensis* but with a more pointed vertex and different male aedeagus. Length 4 mm.

Vertex sharply angled, almost twice as long at middle as basal width between the eyes.

Color: Dark brown with slender pale vittae on vertex. Elytra pale brown, irrorate with darker brown, leaving many pale areas and areolar spots. Veins brown. Face heavily irrorate with brown.

Genitalia: Female last ventral segment with posterior margin roundedly produced. Male plates almost as long as pygofer. Styles with apical third narrowed and produced as finger-like processes. Dorsal portion of aedeagus rather short, narrowed to blunt apex. Ventral paired processes enlarged near apex to form large pointed spines on upper surface which are about one-sixth the distance from apex.

Holotype male, allotype female and male and female paratypes from Shawneetown, Illinois, June 14, 1934 (Ross and DeLong) and June 27, 1934 (DeLong and Mohr).

Holotype, allotype and paratype in Illinois Natural Survey collection. Paratypes in author's collection.

Cloanthanus parvus var. niger n. var.

Resembling *parvus* in size and general appearance but with shorter, blunter vertex and darker in color. Length 3.5 mm.

Vertex blunt at apex, two-thirds as wide between eyes at base as median length.

Color: Dark brown, vertex heavily irrorate with a few pale longitudinal markings. Pronotum with five pale vittae. Scutellum paler. Elytra irrorate with brown, leaving many pale spots and white areoles. Face pale brownish.

Genitalia: Female last ventral segment roundedly produced on posterior margin. Male genitalia similar to *parvus*. The dorsal portion of the aedeagus is short and rather thick and is broadly rounded at base. The ventral paired processes are slender throughout.

Holotype male, allotype female and male and female paratypes from Birmingham, Alabama June 16, 1925, collected by the author. In general appearance this appears to be distinct from *parvus*.

Types in author's collection.

BLACK WIDOW SPIDER (LATRODECTUS MACTANS (FABR.)) DISTRIBUTION IN OHIO

Supplement

FRANK M. SEMANS,
Entomologist,
North Jackson, Ohio

Since the publication of the original paper[1] a number of new records have been added which increase the total number of Ohio counties in which the black widow spider has been found from thirty-two to thirty-seven. The five additional counties are in the area described in the original paper. The thirty-seven counties are as follows (from Oxford to Youngstown): Butler, Hamilton, Warren, Clermont, Clinton, Brown, Adams, Pickaway, Ross, Pike, Scioto, Ashland, Richland, Knox, Licking, Fairfield, Hocking, Vinton, Jackson, Gallia, Lawrence, Holmes, Coshocton, Muskingum, Perry, Morgan, Athens, Stark, Tuscarawas, Guernsey, Noble, Washington, Carroll, Belmont, Monroe, Columbiana, Mahoning. In the hilly area of Ohio, the counties from which no black widow spiders have been reported are: Highland, Meigs, Harrison, and Jefferson. No new locations have been reported since January, 1942.

[1]Semans, Frank Merrick, 1941, "Black Widow Spider (*Latrodectus mactans* Fab.) Distribution in Ohio," O. Jour. Sci., 41: 380, 1941..

Chandler's Parasitology

This new edition of a well known textbook contains an amazing amount of new information and the publisher's announcement of a completely rewritten book is entirely justified. At first glance, however, it looks much like its predecessors due to the fact that the illustrations are the same and many introductory remarks are identical with previous editions. Careful reading reveals that Doctor Chandler has thoroughly covered and appraised recent literature and his labors make the tasks of teachers and research workers easier.

The new size due to smaller margins and thinner paper, we hope, will continue in future editions which will appear after all thoughts of the present paper shortage have passed.

—*C. E. Venard.*

Introduction to parasitology with special reference to the parasites of man, by Asa C. Chandler. x+716 pages, 309 illustrations, 7th edition. 1944. Price $5.00.

REVIEW PAPERS

(Papers appearing in this section are invited reviews of subjects of wide current interest.)

FUELING A GLOBAL WAR[1]

An Adventure in Statecraft

MAX W. BALL,
Petroleum Geologist, Special Assistant to Deputy Petroleum Administrator,
Petroleum Administration for War,
Washington 25, D. C.

My story is a story of the American spirit in action. My theme is a unique adventure in statecraft. My example is a form of government-industry cooperation that has made possible the impossible. Specifically, my example is the fueling and lubricating of the greatest armament the world has ever seen: more planes than ever before swept the skies; more vehicles and armor than ever before roamed the land; more ships than ever before ploughed the seas; more landing craft than ever crawled ashore. The story is one of grueling effort and hard-won success; of achievement through a new form of industry-government teamwork.

THE VITAL MUNITION

Napoleon once remarked that "an army marches on its stomach." Today an army marches—and a navy sails and an airplane flies—on its fuel tanks. More than 65 per cent of all the tonnage shipped overseas is liquid fuel—gasoline, diesel fuel, and fuel oil. Think that over for a moment: The oil required to fuel and support our armament is nearly double the tonnage of the armament itself, the shells and cartridges for the guns, the food, shelter, medical supplies, and creature comforts for the men, the repair parts and replacements for the equipment, and all other supplies.

ARMAMENT WITHOUT OIL

What good would all our armament be without fuel and lubricants? None whatever. Deprived of mobility it would be just so much scrap, useful only on the salvage dump. Without gasoline, a fair-grounds balloon is better than an airplane, and a bicycle than the fleetest staff car built. Without fuel oil a Chinese junk is a better craft than the mightiest battleship. Without lubricants, no plane or gun or tank or car or ship could move through even the shortest campaign. Equipment without fuel and lubricants is as bad as a rifle without cartridges; a good stout club is a better weapon.

MILITARY USE

I am not free to give you figures on the total quantities of the various oil products required, but I can give you a few comparisons, from which you can do your own addition and multiplication. A tank car load of gasoline would

[1]John Adams Bownocker Memorial Lecture given January 16, 1945, through cooperation of the Bownocker Fund, Department of Geology, the Ohio State University, and the Ohio State Chapter of the Society of Sigma Xi.

fill the ordinary civilian's car for nearly 14 peacetime years, but it will fill the tanks of a B-29 only once. Aviation gasoline consumption has increased by more than 1,000 per cent since Pearl Harbor.

Present aviation gasoline requirements for our air forces are 14 times the total gasoline for all purposes shipped to Europe at the height of the last war. Our air forces alone are using more gasoline per day than all the trucks and buses in the United States. If these are the requirements of the air, try to compute the gasoline and diesel fuel consumed by ground equipment—tanks, trucks, tractors, guns, armored cars, jeeps, and all the rest—in western Europe alone. Then add Italy and the Pacific area and the rest of the fronts, and the supply areas back of the fronts. The Navy, which operates on the sea, has more than 140,000 vehicles operating on land. Try to imagine, then, how many the Army must have! When that gets beyond your grasp, stupefy your imagination by thinking how much fuel oil is consumed by the ships of the Navy, Coast Guard, and the merchant fleet, operating on the seven seas. It is greater than the entire marine fuel consumption of the world a few short years ago.

At every beat of your heart enough oil goes overseas to run a car from Fairbanks, Alaska, across Canada, the United States, and Mexico nearly to Central America. Military use and overseas shipments in 1944 would have buried the whole of Manhattan Island under nearly four feet of oil.

ESSENTIAL DOMESTIC USE

Then, when you think you have an adequate conception of overseas and offshore requirements, add essential domestic consumption. War plants and plants making essential goods must run; many of them run on fuel oil or natural gas; all of them require lubricants. Houses and offices and apartment buildings and hotels must be heated; many of them are equipped to burn nothing but oil, and no other equipment can be had. Unless farm tractors and trucks were supplied with gas and oil the production of food would decrease alarmingly. Diesel and oil-burning locomotives must run; otherwise the railroads would face an even greater problem than they do. Unless cross-country buses and trucks can run, the task of the railroads would become impossible and many communities would be marooned without transportation. Unless urban buses and trucks can run, workers could not get to and from their jobs, food and supplies could not be distributed, and the productive activities of our cities would soon be demoralized. Without gasoline hundreds of thousands of workers could not get to their jobs and thousands of executives and professional men could not go about their necessary businesses. Even the ordinary civilian needs to drive a few miles now and then; his pattern of living was designed on gasoline.

Rationing of gasoline and fuel oil, conversion to other fuels and other conservation measures have somewhat curtailed civilian consumption—otherwise military demands could not have been met—but the curtailment has been largely offset by the needs of a vastly expanded war industry. Civilian consumption is considerably below its volume before Pearl Harbor, but is still about two and a half times military consumption. In an industrialized nation, the home front requires even more oil than the fighting fronts.

ALLIED AND NEUTRAL NATIONS

That still is not all. We are not fighting this war alone, thank God, on either the fighting or the production fronts. The armies, the navies, and the air forces of our fighting allies must be supplied with fuel. Their industries and their essential civilian uses must be supplied as well. The civilian economies of liberated areas must be restored as rapidly as possible, for military and productive as well as humanitarian reasons, and oil products bear a large part in the restoration.

It should be said, in passing, that the civilian economies of our allies and of

neutral and liberated nations have not been supplied with anything like the generosity accorded to our own. It has been years since an English civilian, for example; could drive his car to market for the week's groceries or meet a baggage-laden friend at the station.

Except for Russia, most of these oil products must perforce come from the United States. The fields of Latin America and the Middle East are being utilized to the limit of available refining and transportation facilities. Their facilities and output have been and are being expanded as rapidly as time, distance, and availability of materials permit; faster, proportionately, than those in this country. Nevertheless, the producing and refining facilities of the United States must still carry most of the burden. To our own military and domestic consumption, then, must be added a good share of the military and essential civilian consumption of the allied, neutral, and liberated countries.

THE MULTITUDE OF PRODUCTS

The staggering quantities are only half the story. The job is as complex as it is stupendous. Jeeps won't run on diesel fuel or tanks on heavy fuel oil or battleships on gasoline. Planes would be sitting ducks for the enemy if fueled with motor gasoline. Carriers and PT boats don't use the same fuel. The oil that heats an apartment house would not run your car or fuel an industrial plant. Diesel trucks and buses can't use gasoline, and the fuel for diesel locomotives differs from that for diesel trucks and buses. As for lubricants, their variety is bewildering. Motor oil for jeeps won't do for the engines in a carrier. The turbines in a battleship require different lubricants than the generators or the gun turrets or the recoil mechanisms or the ammunition hoists. A B-29 uses 26 different oil products and derivatives. The number of different oil products used in essential industries is too great to enumerate.

Someone has said that winning a war is a matter of having enough of the right things at the right places at the right time, but enough oil to the right place at the right time is no good unless the oil is of the right kind. Each petroleum product, whether aviation gasoline, heavy fuel oil, Arctic motor oil, or axle grease, must be tailor-made for its particular use; it must be made in the right quantities; and it must be where it is needed, when it is needed. Time, place, quantity, *and kind* are the essential elements.

CRUDE OILS AND REFINERIES

Can you visualize the job of meeting these requirements? There are almost as many different kinds of crude oil as there are major oil fields. Some crudes are well adapted to making aviation fuel, some are not. Some are high in total gasoline yield, some are low. Some yield excellent lubricants, others do not. Some make more and better diesel fuel than others. Some are most notable for their heavy fuel oil yields.

Moreover, no crude oil is converted wholly into a single product such as gasoline or fuel oil or lubricants. Every crude yields from a half dozen to a half hundred or more products, the number, quantity, and quality of each depending partly on the character of the crude and partly on the refining processes to which it is subjected.

These refining processes are in themselves numerous and complex, and the units in which they are carried out are adapted to only one general type of operation. Refinery equipment is not ordered out of stock in standard shapes and sizes. Each piece is individually designed and built to produce certain products out of a certain raw material. A plant built to make maximum motor gasoline from East Texas crude cannot be converted overnight to make maximum lubricating stock from Gulf Coast crude; a large part of it would have to be redesigned and rebuilt, and after the change was made its secondary products—furnace oil, diesel

fuel, heavy fuels, and the rest—might be entirely different from what it made before.

Every one of the secondary products from every plant is important, for the secondary product of a plant is the primary fuel or lubricant in some specific use. It follows that if the right product is to be at the right place at the right time in the right quantity, the right crude must be processed in the right refinery, far enough in advance to permit delivery where needed when needed.

To produce the crude oil in the respective fields, get each grade to the refineries best fitted to use it, make the needed products, and distribute the products to the points of use requires a far-flung inter-related system of wells, refineries, pipe lines, tankers, tank barges, tank cars, tank trucks, terminals, ports, and loading facilities, each part of which must be correlated with the rest of the system. Supplying the world with oil, even in peace time, is a complex business.

WARTIME COMPLICATIONS

Into this already complex business the war has introduced endless new complications. Millions of barrels of new products have been required, specifications for old products have been changed, increased yields of some products have been demanded and decreased yields of others, and the relative demand for each product has changed from month to month. The needs of individual refineries for crudes of particular characteristics have shifted. The supply of some crudes has diminished and of others has increased.

Many tankers depended on to carry crude from the fields to the refineries have been sunk by the enemy or diverted to carrying products overseas. Overland transportation by pipe line, tank car, tank truck, and barge has had to replace coastwise and lake shipping. New pipe lines have had to be built and old ones relaid or reversed. Terminal and loading facilities have had to be pooled. The entire oil transportation system east of the Rockies has had to be revamped, one of the most intricate transportation systems in the world, built up through more than 50 years of trial and error.

Shortages of materials and men have imposed further difficulties. The oil business uses huge tonnages of steel, copper, lead, and other metals, great quantities of chemicals, thousands of specialized geologists, chemists, and engineers, and hundreds of thousands of highly-skilled workmen.

Called on for a great expansion of output, it would normally have increased its use of both materials and men. Yet both materials and men have been needed by the armed services and by other essential industries. Greatly increased output of petroleum products has therefore had to be achieved with a decreased amount of materials and fewer men. Fueling and lubricating a global war wouldn't be half so tough if it didn't have to be done in wartime.

ONLY THE INDUSTRY COULD DO IT

Have I succeeded in giving you a conception of the magnitude and complexity of the job? Five years ago almost any oil man would have declared the task impossible. No informed person who could have foreseen the needs would have believed that the petroleum industry could supply them. Yet the petroleum industry is doing it. No one else could possibly do it. Only an industry with a pre-war total initial investment of 15 billion dollars, the second largest industry in the United States, could think of doing it. Before the war the industry was accustomed to producing and refining upwards of three million barrels of oil per day, and delivering the products to cross roads and main street intersections, from coast to coast and border to border. Only an industry with the competence, the technical skill, the adaptability, and the ingenuity to carry on such far-flung, complex, and constantly changing operations as a daily routine—only such an industry would have known how to start. That fact is obvious. A second fact

is almost as obvious: Although the industry alone could do the job, it could not do the job alone, for a number of reasons. In the first place, it lacked the necessary coherence and centralization; it was too competitive.

THE COMPETITIVE SPIRIT

Those of you who still think of the oil business as a monopoly, an octopus with one head and many tentacles, are about thirty years behind the times. Those filling stations at cross roads and street intersections cost money, plenty of money. Would a monopoly have built them to get your business? A monopoly would get your business without such expenditures; you might not like to go five miles instead of five blocks to get your gasoline, but you would do it—and use more gasoline in the doing. Would a monopoly have cut the price of tax-free gasoline in two from 1920 to 1938? The oil business did. Would a monopoly have increased the average octane rating of your gasoline by 10 points in the same period while it was cutting the price in half? The oil business did. The idea that the oil business is a monopoly is as out of date as button shoes and hobble skirts.

Those filling stations, the improved quality represented by those extra octane numbers, and those price cuts have come about because thousands of producers, refiners, and marketers, big and little, are each trying to get more business and keep it. The oil man's creed about additional business is simple: Find it, create it, develop it, or take it, but get it. An oil man scarcely dares to take a nap, lest some competitor discover a new field or develop a new process or tie up a market that he could have had if he had stayed awake. If there is an industry more competitive than the oil business, count me out of it.

Now all this competition is a grand thing in time of peace. It means higher quality, lower prices, better service; millions of dollars a year spent in research, technologic advancement so rapid that a plant may be obsolete by the time it is completed, all of which redounds to the public good. It may also be a grand thing in time of war, provided that competitive practices do not interfere with a coherent, unified, one-for-all effort to do an all-out emergency job.

Unfortunately, some competitive patterns do just that. A producer who has a surplus of drilling rigs doesn't ordinarily turn them over to his neighbor who may have none, yet it may be important to the war effort that the neighbor's lease be drilled. A refiner who has contracted for a crude supply doesn't normally divert part to his competitor, even though the competitor's plant might make more 100-octane gasoline from it. A marketer with excess terminal capacity doesn't usually invite his competitors to use the excess. A company that has spent a million dollars developing a process to make better gasoline at lower cost isn't likely to throw it open for the world to use. Yet some of these things were bound to be necessary. Could and would oil men forego competitive practices so far as required for the common good?

GUIDANCE AND PROTECTION NECESSARY

Suppose they did? Suppose that every man in the oil business could lay his ingrained competitive instincts completely on the altar of the war effort, who would tell him how to make his sacrifice, where his tools or his crude oil were most urgently needed, what competitors would make the best use of his processes or his excess facilities? Who would tell him how much to give and to whom? Most important of all, who would protect him from fine and imprisonment for doing things that in war are called cooperation but in peace are called collusion? Oil men hesitate to lunch with a competitor, for fear of an anti-trust investigation.

Moreover, who would protect the industry from its own sharp-shooters, those who might refuse to cooperate, who might knife a competitor behind the screen of war activity? Such sharpshooters would be few and under normal conditions unimportant, but one small monkey wrench can wreck a big machine, when the machine is running at the speed the oil industry would have to maintain.

WHO WOULD PLAN AND PROGRAM

Second, if the industry were to attempt the job alone, who would plan and program it? Who would coordinate the productive efforts of thousands of producing, refining, transportation, and marketing companies to meet the needs of a dozen armed services and a score of civilian economies? Who would analyze and predict the needs of our own armed services, merchant marine, and civilian economy, those of our allies, and the civilian economies of the neutral and liberated countries? Who, when such a program of needs had been drawn for as far ahead as might be, would determine how much of which product should come from where, in order that the needs might be met?

If the tremendous needs of the war were to be met with the limited materials and men available, the output of every well, every natural gasoline plant, every refinery and every unit in every refinery, would have to go to the plant, the port, or the consumer where it would do the most good. The transportation of every barrel would have to be planned so that tanker space, always in short supply and subject to enemy action, might be utilized to the best advantage and wherever possible be replaced by overland transportation. To save transportation, supplies for each point of use should be lifted from the nearest available source, a matter that in itself would require far-sighted programming.

Such planning must not only cut across all competitive lines, it must be world-wide in its scope, cutting across all international boundaries. Here clearly was a task beyond the capacities of a vast but competitive industry.

WHO WOULD DEAL WITH FOREIGN POWERS

Even though the industry could legally achieve a degree of unity enabling it to disregard competitive boundaries, it could not without governmental powers disregard international boundaries. Only an agency of government could deal with allied and neutral governments, gathering the information, conducting the negotiations, and doing, with them, the world-wide planning necessary to success.

WHO WOULD DEAL WITH DOMESTIC AGENCIES

Who, for that matter, would deal with the numerous agencies of our own government that in wartime perforce have some connection with the oil effort? There are thirty to forty of them—I have not taken time to count them—including the Geological Survey, the Bureau of Mines, various bureaus of the Treasury Department, the Department of Justice, the Interstate Commerce Commission, the Office of Defense Transportation, Defense Plant Corporation, Defense Supplies Corporation, the War Manpower Commission, the Office of Price Administration, the War Production Board, and a host of others. With the necessary wartime concern of these agencies in his business, an oil man would almost have to spend his full time in Washington, with a retinue of guides and special representatives, if he had to deal directly with all of them.

If his war effort were to be effective, there must be an agency with which he could deal, and with which alone he need deal except as it took him to other agencies.

WHO WOULD OBTAIN THE MATERIALS

Finally, in wartime Washington with its vital control over vital materials, who would get the industry the materials for its wartime needs?

The industry requires iron and steel and copper in large quantities. It requires pipe and pumps and valves and compressors and engines and trucks and instruments. It requires tires and hose and rubber tubing. It cannot function without tankers and tank cars and tank barges and tank trucks. It uses chemicals and lots of them. It requires a hundred other things. The oil business is not only a huge producer; it is also a voracious consumer. How, in an ever-tightening market, would it get the diet of materials it would have to have?

Most of the materials were in limited supply. Already the government had set up agencies to apportion the available quantities where they would do the most good. If a half million producers and refiners and distributors should descend upon the agencies, each clamoring for what he wanted, would each of them get what he should have and only what he should have for his war effort? Would the industry as a whole get what it should have? Would the limited supply that could be allocated to the oil business be placed where it was most urgently needed? Obviously not. Someone who knew the problems and the needs of the business as a whole would have to screen and consolidate the applications, then press the industry's claim for enough materials for its job, and then see that they were efficiently used where they would do the most wartime good. There would have to be what Washington has come to call a "claimant agency."

THE GOVERNMENT MUST PROVIDE AN AGENCY

No, the industry as such could not do the war job alone; there must be an agency to guide, coordinate, and where necessary direct the effort, to represent the war-conceived necessities of the industry, to deal with foreign governments, and, in conjunction with them, to plan the worldwide program that the industry would carry out. The government itself, through an agency created for the purpose, must guide, coordinate, direct, and represent.

Thus, inescapably, the Office of Petroleum Coordinator was established on May 28, 1941, with Secretary of the Interior Ickes as Coordinator, and on December 2, 1942, this was changed to the present Petroleum Administration for War, PAW for short, with Mr. Ickes as Administrator.

OPERATION OR COOPERATION

At the outset, a vital decision had to be made: Should the government take over and operate the industry? There were men who thought that only through government operation could competition be subdued into cooperation, could the know-how of the industry and the authority of the government be brought together. There were men who believed in government ownership in peace as well as war, and who thought this an opportunity that should not be missed. There may even have been men—little men—whose fingers itched for the giant authority that government operation might give them. Advocates of government operation were not wanting.

Mr. Ickes, however, had a greater vision, a plan by which the industry and the government should go to work together. The tremendous strength of the industry, the vigor and virility bred into it by competition, should be kept unimpaired and be utilized to the full in the mightest war effort man had ever seen. From the industry's great store of talent should be drawn in large part the government organization to aid and guide and administer the effort. Teamwork between the two should be assured by industry committees working intimately with the administrative units. Thus closely integrated, each doing the part that it alone could do, industry and government would do the job together. Whether we may think as much of Mr. Ickes as Mr. Roosevelt has shown that he does, or as little as Mr. Dewey, for example, has said that he does, one fact is clear: his handling of the oil situation during the war has been that of a great statesman.

STAFFING THE AGENCY

His first act was to pick as Deputy Petroleum Administrator, to run the job, an outstanding oil company executive, the type who combines administrative force with vision and public spirit, Ralph K. Davies, executive vice-president of Standard of California.

Some men would have been hesitant lest they be accused of favoritism or would have been fearful that oil men might grind private axes in public positions.

Mr. Ickes had more faith in human nature. He encouraged Mr. Davies to staff from top to bottom with men who knew oil and the oil business, drawn chiefly from the industry, with a leaven of such men from government technical bureaus, state agencies, and educational institutions as were qualified and available.

To assure breadth of knowledge and balanced point of view, the men were drawn from all branches and phases of the industry, from such related industries as the construction and supply companies, from all parts of the country, and from big and little companies alike. The great major companies and the small but vital independents were evenly represented so far as possible. For fairness and impartiality, reliance was placed on the integrity and patriotism of the men selected and their diversity of background. No man passes on any matter that deals with the company with which he was formerly connected. If anyone did attempt to favor a former affiliation, it would most certainly be caught by some one of the other men through whose hands it must pass, men with different former affiliations. These precautions have proved notably unnecessary. An able and unselfish executive who spent three years in PAW, and left recently to go back to the industry, remarked on leaving that he had not seen a single attempt by any PAW man to favor his former company. After all, these are high-type men; such men are prone to intensive singleness of purpose; and the purpose of all of them is to win the war.

POLITICS AND ECONOMICS

Political affiliation and economic views, likewise, were to be neither asked nor considered in staffing the organization; men were to be selected for their knowledge and ability, not their politics.

I have spoken in the past tense, but what was true at the start is true today. I am a newcomer in the organization. I doubt that Mr. Ickes agrees with some of my published views on planned economy, but that did not prevent my being drafted for service. No one has asked me whether, in the last four presidential elections, I have voted for one man or for four; so far as PAW is concerned, no one cares. Almost any day, in the executives' lunch room, you can hear a rampant Republican, or a half dozen, staging an argument with some equally rampant New Dealer, openly and fearlessly, or a disciple of Adam Smith battling with a disciple of Stuart Chase. But the politics and the economic theories are left in the lunch room, along with the tips and the paper napkins. They have no part in what goes on in the offices upstairs.

THE TEAM-WORK IDEA

Mr. Ickes' next step, after appointing Mr. Davies, was to call representatives of the industry together and explain his plan and his purpose. He emphasized that the spirit of both plan and purpose was cooperation rather than coercion. The oil men listened politely, then went home to tidy up their bomb-proof shelters. These men, you must remember, had been listening for ten years to proposals from Washington, ranging from making the oil business a public utility to expropriating it. Small wonder that they were skeptical.

Skepticism lessened, however, when the plan began to function, and the industry discovered that it was a full-time working partner, participating fully in the partnership business and in the partnership councils.

CONTACT WITH THE INDUSTRY

One of the first things to reassure it was the dispersion of the organization into intimate contact with the industry, instead of its concentration in cloistered halls in Washington. Mr. Davies decentralized his staff; got as many of his men as practicable out into district offices, where the derricks and refineries and bulk stations are. An oil operator no longer had to go to Washington to present his needs or views; consideration was given on the spot by men trained in the

operator's special branch or function of the industry. Each district office had a staff trained in each function of the business: production, natural gas and natural gasoline, refining, transportation, and distribution.

In Washington each function of the business was represented by a division headed and staffed by specialists in that function. The staff included men with established reputations as geologists, drillers, production engineers, field superintendents, pipe line builders and operators, refinery engineers, chemists, refinery superintendents, research men, sales managers, traffic men, station managers, economists, lawyers, accountants, and all the other specialties that go to make up the vast and complex organism of the oil business. The industry found its needs and its problems in the hands of men who knew them and whom the industry knew.

KEEPING THE COOPERATIVE ATTITUDE

Even an organization drawn largely from the industry, however, might lose the cooperative touch if allowed to set itself apart. The possession of authority is a great temptation to use it unsparingly. Coercion is often simpler than cooperation. Arbitrary decisions are more quickly and easily reached than joint decisions. Autocracy, on the surface, looks more efficient than democracy. Men might be pardoned for thinking the fastest and cheapest way to get the job done would be for PAW to decide what the industry needed, tell the industry what to do, and let the industry then go and do it.

To their credit be it said that few men in PAW were inclined to this easy but dangerous fallacy, and they were soon set right. The men at the top knew better; so did virtually all the men in the ranks. The job was too big to be directed by a few men temporarily vested with authority. The problems of the war effort were too great to be analyzed and solved, unaided, by a government agency.

The key lay in working together. PAW must not become the autocrat, industry the menial. The relationship should always be one of partnership.

How establish and maintain that relationship? How counteract the natural tendency of government bureaus to become autocratic, and of industry to look with hostility on government guidance? How make the effort a joint effort, putting behind it all the brains and vigor of the industry, all the power and knowledge of the government? Mr. Ickes and Mr. Davies had the answer; the right answer, as time has proved.

THE INDUSTRY COMMITTEES

In each of PAW'S districts industry committees were formed, one for each functional division of the industry: production, natural gas and natural gasoline, refining, supply and transportation, distribution and marketing. These committees work with the corresponding PAW functional directors, district and national; the production committee, for example, with the district and national directors of production. The chairmen of the five functional committees, with a chairman chosen for his grasp of all the functions in the district, constitute a district general committee, working with PAW on matters affecting all branches of the business in the district. Both the general and the functional committees may have special committees and subcommittees performing specific duties or dealing with special problems, such as committees on manpower, construction, materials, technical data, research, and the like; whatever needs to be covered, these district committees cover. Most of them have paid staffs; some of them have full-time executives. They bear all the costs of their own work, and a great many of the members give more time to their committee work than to their company duties.

Note how these committees differ from the industry advisory committees attached to so many government bodies. They are not window dressing, existing to give occasional advice and to create an illusion of cooperation. They are

working bodies. They are advisory in the sense that they have no power to issue orders, but it is a rare district order that is not in accord with their judgment. They supply most of the facts on which action is based. If more facts are needed, they find them and analyze them. On the one hand they recommend actions to be taken; on the other they explain to their associates in industry the reasons for the actions. They work out solutions to the multitude of problems that arise. They carry out approved programs. Many of the ablest executives in the oil business serve on these committees, and some of them have given their full time to the administration of programs of particular difficulty, programs that averted disaster through their patriotic efforts.

These committees are a far cry from the purely advisory committees of other days and other agencies, useful as some of them may have been.

SELECTING THE COMMITTEES

How were the committees selected? Mr. Ickes and Mr. Davies asked the industry to submit nominations. Anyone in or connected with the industry could submit as many names as he chose. The industry responded with thousands of nominations, naming several hundred men. From these the committees were appointed, care being taken that on each should be balanced representation between the major and the independent companies, big and little, and that all points of view should be represented.

As thus constituted the committees represent an impartial working cross-section of the best talent in each district.

More than 1,000 men serve on these committees; 1,000 picked men of the industry, whose willing services could not be had in any other way.

THE PETROLEUM INDUSTRY WAR COUNCIL

The cooperation I have so far described is at the district level, but the plan does not stop there; it extends to the top. The industry body which deals with matters of national scope, and through which the industry's entire effort is unified, is the Petroleum Industry War Council, PIWC for short, made up of 78 top-flight industry executives.

The Council is composed of, first, the chairmen of the district general and functional committees; second, the heads of the nineteen trade associations in or dependent on the industry; third, outstanding company executives, both major and independent, who happen not to be included in one of the other categories; and fourth, ex-officio, the chairman of the Foreign Operations Committee, of which more anon.

The Council too has its committees, a long list of them, covering the same functional activities as the district functional committees and a number of other things such as conservation, economics, renegotiation, disposition of government-financed facilities, and national oil policy. These committees draw upon the entire knowledge of the industry as well as the knowledge of PAW, they confer with the appropriate PAW divisions, and they report to the Council or to PAW through the Council.

The Council meets regularly with the chief executives of PAW, and at these meetings all the major problems and policies of the *worldwide oil situation* are on the table. The Council, working with the executives of PAW, is the powerhouse of industry-government cooperation.

GLOBAL ATTENTION

Notice that phrase, "the worldwide oil situation." The functions of PAW do not stop at the water's edge; the cooperation of the industry is not circumscribed by our national boundaries. Every gallon of petroleum products produced or used by the United Nations anywhere in the world is within the sphere of interest and activity.

PAW's studies of problems and supplies outside the United States are carried out by three foreign divisions headquartered in Washington, devoted respectively to foreign production, foreign refining, and foreign supply and distribution. The corresponding industry body is the Foreign Operations Committee.

The Foreign Operations Committee is to the foreign situation what the Petroleum Industry War Council is to the domestic situation. It too has numerous committees, functional and geographic, working on every phase of foreign production, refining, transportation, and distribution, as intensively and devotedly as the committees working on domestic problems.

PAW's foreign divisions also cooperate closely with foreign governments and with agencies of our government concerned in foreign affairs, particularly, as to the latter, with the State Department, the Foreign Economic Administration, and the armed services. Great Britain is represented in Washington by a British Petroleum Representative. Without whole-hearted British cooperation much of the effectiveness of the worldwide effort would have been lost. Canada's Oil Controller has a representative in the PAW building. Other governments either have oil representatives in Washington or keep in touch through their embassy staffs or their home offices.

Thus the world is covered, and many interesting as well as important things are given attention: Facilities for making 100-octane gasoline in the Dutch West Indies or on the Persian Gulf; multiplying the amount of oil coming out of the Caribbean region; providing additional refining facilities for Russia and for Saudi Arabia; possible utilization of liberated refineries that the Germans left too fast to wreck—these are samples of the things considered. The petroleum problems of a global war are studied under a global microscope and solved by global cooperation.

HOW IT WORKS

If all this seems complex and confusing it is only because the business to be done is of infinite variety. In practice the operation is direct and efficient. Let's take an illustration, hypothetical and simpler than most problems:

One fine morning the Army calls up PAW and says that after a certain date it will need an increased monthly supply of a certain special lubricant. The directors of PAW'S divisions of production, refining, supply and transportation, distribution, materials, and program get together and if necessary get in touch with their respective district directors and the industry committees concerned. The matter may be taken up in the domestic operating committee, for consideration whether the demand can be met by decreasing some civilian use, whether transportation can be made available to deliver the product where the Army wants it, whether the program for other products would be thrown out of gear. The foreign divisions may be consulted to see whether an overseas source, closer to the point of use, could be developed. At length, and more quickly than you might think, a decision is reached that the special oil can best be made, with minimum disturbance of the output of other essential products, by Gulf Coast refineries using a certain grade of Texas crude. The directors of production and refining notify their respective district directors at Houston. The district director of refining lays the problem before the district refining committee and together they decide that plants A, B, and C at Houston and Beaumont can best do the job. After consulting with the plant managements they find that plants B and C will need certain additional equipment and half a dozen skilled men to install it, and that the new installation at plant B will have to be financed by the government. The plants prepare for the necessary change-over and the district office informs Washington of the materials, manpower, and money needed.

Meanwhile the district director of production has met with the district production committee and arrangements have been made for the diversion to plants A, B, and C of the necessary supply of the desired grade of crude. He too reports his results to Washington.

In Washington the request for materials, men, and money gets immediate attention. The director of the materials division, after studying his own files and perhaps those of two or three other government agencies, and discussing the matter with the PAW construction officer, decides that plants M and N at Pittsburgh and Gary can supply the requisite sheets and shapes of special steel, and that plants X and Y at Marietta and Terre Haute can fabricate them into the necessary pressure stills without undue delay to other urgent war orders. Then he asks the War Production Board to allocate the necessary critical materials. With the support of the Army, he convinces them that the need is great enough to warrant the allocation, even though the materials must be taken from the tank or some other urgent program.

The critical materials are allocated and the production and fabrication of the steel are given a high priority, high enough to insure plants M, N, X, and Y of being able to make delivery in time. The director of materials sees that the orders are placed and manufacture started. Then his men keep a constant check on the plants until the orders are completed and shipped, and he keeps plants B and C informed of progress.

While thus engaged the director of refining has taken up the matter of financing plant B with Defense Plant Corporation, a thorough check has been made of the need and the security, and DPC has agreed to loan the plant the money needed.

Meanwhile PAW'S labor counselor has gone to work to get those six needed skilled workmen. He and the manpower committee in Houston may try to borrow men from other refineries. They may confer with everybody from the War Manpower Commission in Washington and its Regional Director in Dallas clear down to half a dozen local draft boards. They may get an improved labor priority, arrange for stationing recruiters in favorable employment offices, or even get the War Labor Board to grant a wage adjustment. By one means or another they get the required men.

Eventually the materials arrive and the men go to work. The district refining and manpower committees and the district directors keep in constant touch with the work, check the technique of the installation, try to keep the men on the job and working at what should be wartime speed, and hasten progress in every way they can. When operations start, they check and advise until the new unit is in production.

By the day appointed, the Army begins to receive its increase of the special lubricant. A job has been done, and if you think that it took some doing, you should follow some of the tough ones!

Note the part borne throughout by the industry committees. Only in obtaining the allocation of materials and money was PAW forced to travel alone. In everything else, from the first to the final operation, PAW and industry committees worked side by side to get the job done.

MONETARY VALUE OF COOPERATION

The services of the men who serve on the industry bodies and the men who serve under them in industry capacities are beyond price. Think what an army of government men would be required to do the same job. The oil fields and refining centers and shipping terminals would be crawling with them. If they were to be competent they would have to be taken from the industry—there would be no other source—which would leave the industry helpless.

Their value can not be measured in money, but what they save the government in dollars and cents alone should bring prayers of thanksgiving from the taxpayers.

BATTLES OF THE COUNCIL CHAMBER

Has the cooperation between the government and the industry always been conducted in a roseate glow of sweetness and light? Not by a couple of thousand

light years. Successful oil men are forceful individuals, with strong wills and strong opinions. Some are even gifted with strong language. They do not leave these assets at home when they accept service with PAW or on an industry committee.

Not all the pitched battles of the war have been in Europe or Africa or the Pacific area; some have been fought in Petroleum Industry War Council meetings with PAW. Some pretty stiff engagements have taken place in district offices.

These disputes are the exception, not the rule, but they are not to be taken lightly. Some of them have the bite and venom so often characteristic of a family row, and like any other family row they could lead to estrangement and even to divorce. That they have not done so is due to the centripetal force of a common objective: The winning of the war. Oil men, inside the government and out, are bent on victory, and their disputes are always about "how," not "whether."

THE PRESERVATION OF THE INDUSTRY

Joint concentration on the main objective is furthered by a common secondary objective, namely, the preservation of the industry. Mr. Ickes and Mr. Davies announced at the outset their determination to keep the industry intact, with its external and internal competitive vigor unimpaired, and to leave it intact and unimpaired when the war is over.

When the leaders of the industry sit in Council with executives of PAW they know they are dealing with men who have the ultimate interests of the industry at heart, men who for the most part came from the industry and expect to return to it and want a healthy industry to return to, but who are determined, nevertheless, that no consideration for the industry or for anyone in it shall interfere with winning the war. On this the industry men are equally determined, first because they are patriotic Americans, and second because, if the war is not won, there will be no free and competitive oil industry. Under such circumstances agreement far outruns disagreement, and performance outruns both.

CASUALTIES OF WAR

The record of maintaining the industry intact has not been perfect. Some producers and refiners and many bulk and filling station operators have been caught by the economic dislocations of the war and been forced to fold up. A few individualists have been unable or unwilling to accommodate themselves to the unavoidable paper-work of a government-guided cooperative effort and have quit in disgust. These casualties must be charged to Hitler and Hirohito, however, and not to Uncle Sam.

Against them may be set those who, but for the efforts of PAW, would have failed through lack of materials or crude or manpower, and those, particularly small refiners, who through government financing, or through diversion of crude to their plants, are stronger now than when the defense program started. If there had been no PAW, the industry's casualty list would almost certainly have been much longer than it is. And when the war is over the United States will still have a strong and hotly competitive oil industry, made up of majors and independents, little companies and big, in about the same balance as before.

THE THIRD PARTNER

In addition to the government and the industry, there is a third partner in this adventure, the man who owns a car or an oil furnace. His part is to use as little as possible.

How many of us save gasoline by never driving more than 35 miles an hour? How many of us, if we have saved a little gasoline, spend it on a Sunday excursion or a trip to a football game? How many of us make it a point to know a truck driver or station operator who will slip us an extra ten gallons? How many of us

lie to the ration board to get a higher ration rating than we need? How many of us unblushingly buy on the black market? How many of us, in short, make a practice of chiseling on our boys overseas and essential users at home?

Don't misunderstand me when I mention the boys overseas. The five gallons you use for a fishing trip will not come out of their allotment. They'll get what they need if every civilian in the United States has to walk or stay home. But that five gallons may be needed to take some war worker to and from his job, some overworked doctor on his round of calls, some Red Cross worker on an errand of mercy, some public utility service man to stop a house from being flooded with gas or a basement with water. Whatever your wishful-thinking friends may tell you at the club or on the street corner, there is not enough gasoline to go around, and what you use unnecessarily someone else must do without. The public is a necessary participant in this unusual and effective partnership.

A UNIQUE ADVENTURE

There you have it: A unique adventure in statecraft on an unprecedented scale.

Dozens of government agencies, now and in the past, have had their industry advisory committees. Advisory bodies, prompting from the wings but taking no part in the performance, have been a dime a dozen. At the other extreme, totalitarian countries have taken over whole industries or coerced them into doing the will of the State. Even some democratic countries have unified the war effort of an industry by assuming its direction and eliminating its internal competition.

But never before, so far as I know, have a great government and a great industry joined in close, coherent, and yet independent team-work, with the industry directing its own effort, with government aiding, guiding, and directing only where imperative, with every precaution to maintain competitive structure and competitive spirit unimpaired, with freedom of enterprise conserved and utilized instead of suppressed.

Here is something that students of political science may well study, against the day of another emergency which we hope may never come.

A PATTERN FOR PEACE?

Whether there is anywhere within it anything of a pattern for peace I also leave with you to study. Such tentative thoughts as I may express are purely my own, and are strictly unofficial.

My own belief is that when the emergency is over such authority as PAW has, of which it has had to exercise very little, should vanish into the pages of history and PAW with it. In my opinion any form of government control, beyond what policing may be necessary, will lead eventually to that worst of all forms of monopoly, a monopoly controlled by government.

I am opposed with equal vigor to economic planning dominated by government. I fail to see how it can succeed without killing competition, which has brought us, to stick to oil as an example, more gasoline of better quality at half the price in twenty years.

I fail to see, moreover, how it can succeed without going the whole road toward a government-controlled economy, which is to say statism as exemplified in Germany, and every step toward statism is a step away from democracy and freedom.

I wonder, though, whether this adventure in statecraft has not given us a glimpse of another possibility, the possibility of a measure of economic planning by joint industry-government consultation. PAW's experience has taught us that leaders of an industry and government representatives who know their problems can consult together for the common good, and that in such consultations

the industry men, jealous as they may be for their competitive positions, are as responsive as the government men to the needs of the common welfare. Is it impossible that they would be equally far-sighted and public-spirited in time of peace?

Leaders of industry have often suggested that if the anti-trust laws would permit them to get together they could curtail the evils of competition and yet retain its benefits. Perhaps they could, but I doubt that the public is willing to risk that the end would be price fixing and monopoly. It's a risk that I should not care to advocate. But if the government itself were a participant, through men familiar with the industry and sympathetic with its problems, the dangers might be avoided and the benefits gained.

These are tentative thoughts, as I have said; idle speculations to be revived, perhaps, when the emergency is over.

THE JOB GOES ON

But the emergency is not over, and the job goes on. The war demands more fuel and lubricants now than ever before. The industry and the government are determined that the demand shall be met, fully and without stint. They are supremely confident that together they can do it, because they know what they have already done. Only a miracle could have done it, the miracle of a government-industry plan that worked.

Yes, it has worked. In the five and one-third years since Germany marched into Poland:

Daily crude oil production has been increased by nearly 36 per cent.

Daily refinery throughput has been increased more than 41 per cent.

Output of 100-octane aviation fuel has been increased by more than 5,000 per cent.

Overland transportation to the East Coast, to replace tankers lost or diverted, has been increased by 5,400 per cent.

The largest crude oil pipe line in the world, 24 inches in diameter and 1,340 miles long, has been completed.

The largest pipe line in the world for carrying refined products, 20 inches in diameter and 1,475 miles long, has been completed.

9,033 miles of other pipe line have been completed, of which 3,150 miles have been dug up and relocated; 3,317 miles have been reversed in carrying direction; and 436 miles of gas line have been converted to oil. Thus a total of 15,600 miles have been put to work to replace tankers sunk or diverted to military use.

101,500,000 barrels of oil have been saved by conversion of heating facilities to other fuel.

Civilian gasoline consumption has been decreased by 16½ per cent.

Every overseas military need has been met.

A minimum of hardship and inconvenience has been visited upon the civilian population.

The needs of the allied and neutral world have been cared for by an integrated global program.

Without fail, except for difficulties of Army transport, the right product in the right amount has been at the right place at the right time.

IT COULDN'T BE DONE

It couldn't be done, ladies and gentlemen, and it has been done. Something new in government-industry cooperation has taken place, and the impossible has been made possible. Oil, the most vital munition of them all, is fighting and winning on every front, and a unique adventure in statecraft is succeeding.

BOOK NOTICES

Aquatic Plants of the United States

Fourth in the series of American Natural History Handbooks from Cornell University is a volume on aquatic plants of the United States by Prof. W. C. Muenscher. Treatment is given those species of vascular plants "which normally start in water and must grow for at least a part of their life cycle in water, either completely submersed or emmersed."

The book includes an introduction, key to 50 families, brief family descriptions, generic and specific keys, with statements of habitat and range of each species. References to other literature are appended to some discussions of families and genera.

The outstanding feature of the work is the assemblage of excellent illustrations by Miss Abbe and Mr. Nickau. Almost all of the approximately 450 species treated, are figured. Most of the drawings are habit sketches, but many show details of flowers, fruits, seeds, roots, seedlings, pollen grains and other specialized or diagnostic characters. Distributions within the U. S. are stated in the text, but also are indicated by maps by states. Some of the maps are misleading because of incomplete data. Maps showing occurrence of species in every state seem unnecessary.

The brief introduction includes a few random notes on distribution, reproduction, storage and treatment of seeds for planting, and weight of seeds. Nothing exhaustive is presented. The discussion of reproduction, for example, includes two sentences. Portions are redundant. The data in Table 1, p. 4, could have been stated in one sentence.

Difficulty will be met in using the keys, since characters absent at flowering time in many species are referred to. While the descriptions show no improvement over those already extant, especially with regard to terminology, the author's notes from wide field experience are of interest. The figures, however, appear to be the useful part of Professor Muenscher's work which is, in all, a worthwhile compilation of information concerning some of the aquatic plants of the United States.

Aquatic Plants of the United States. Walter Conrad Muenscher. Comstock Publishing Co., Inc. Cornell University. Ithaca, N. Y. 364 pp., 157 plates, 400 maps, glossary, index. Price $5.00. 1944.

Coat-Color Change in Weasels

In this study the authors tested the effects of the duration of light upon the seasonal coat-color changes of weasels. The length of the light period in the day and night cycle was controlled by the use of artificial illumination and shifting the caged animals into a dark room. Control animals were maintained in each experiment. Individuals of two different species of weasels were used for this study: *Mustella frenata noveboracensis*, the New York Weasel, and *M. cicognanii cicognanii*, Bonaparte's Weasel.

Changes of coat color in both species was accomplished by shedding of old hair and the growing out of new hair of a lighter or darker shade. This coat-color change was found to follow a pattern upon the body. In general this was from the ventral towards the dorsal surface.

Periods of reduced light duration induced moulting and the regrowth of hair of a lighter shade. Increasing the duration of daylight also induced moulting and the regrowth of hair of a darker shade. By reversal of increase or decrease of the daily light duration, incomplete mounts were obtained in both directions. By proper manipulation of the direction of light duration changes, it was possible to leave an animal for some time with parts of its body covered with hairs from three consecutive growths of hair.

The data from this study indicates that temperature change was not a factor in pelt modification or color cycles in these two species of weasels. Following Bissonnette's work on ferrets and Lyman's study of the varying hare the authors express the opinion that the stimulus for coat-color modification is received through the eyes and probably acts through the anterior lobe of the pituitary gland; also that the thyroids and sex glands are not essential to elicit this response.

—*Wilbur M. Tidd.*

Experimental Modification and Control of Moults and Changes of Coat-Color in Weasels by Controlled Lighting, by Thomas Hume Bissonnette and Earl Elmore Bailey. Annals of The New York Academy of Sciences, Volume XLV, Art. 6. Pages 223–260, 7 pls., 1 graph. April 7, 1944. Published by The New York Academy of Sciences, Central Park West at Seventy-ninth Street. Price $0.75.